

Journal of Student Research 2023



University of
Wisconsin-Stout
Wisconsin's Polytechnic University

University of Wisconsin-Stout
Journal of Student Research
Volume XXI, 2023



University of Wisconsin-Stout

Copyright © 2023

University of Wisconsin System Board of Regents doing business as University of Wisconsin-Stout.

All rights reserved. No part of this book may be reproduced in any form without the permission of the University of Wisconsin-Stout.

University of Wisconsin-Stout Journal of Student Research, Volume XXI, May 2023.

Peter Reim

Editor-in-Chief

Anne Hoeltke

Director: Office of Research and Sponsored Programs

Office of Research and Sponsored Programs

University of Wisconsin-Stout

201/202 Robert S. Swanson Library and Learning Center

Menomonie, WI 54751

(715) 232-4042

Publisher's Cataloging in Publication Data

Names: University of Wisconsin--Stout, publisher.

Title: Journal of student research / University of Wisconsin Stout.

Other titles: Journal of student research (Menomonie, Wis.) | J. stud. res. (Menomonie Wis.)

Description: Menomonie, WI : University of Wisconsin-Stout, 2002- | Annual.

Identifiers: LCCN 2002211792 | ISSN 1542-9180

Subjects: LCSH: University of Wisconsin--Stout--Students--Periodicals. | University of Wisconsin--Stout. | FAST: Students--Research. | University of Wisconsin--Stout. | Periodicals.

Classification: LCC LD6150.75 .A28 | DDC 370

LC record available at <https://lcn.loc.gov/2002211792>.

Foreword

A Swipe, a Swoosh, and a Sweep

Dear Readers,

If you scroll back a couple of swipes from this page, you will arrive at the cover of this, Volume XXI of the *Journal of Student Research* (JSR). There you will see two new things. The first is the cover art itself, produced by Graphic Design student Alex Redetzke. Over the years, the JSR has richly benefited from the fresh and expressive work of graphic designers like Alex. Secondly, you will see something in the lower left corner—the new UW-Stout logo.

Commercial logos are a fact of modern life and impact our awareness of large enterprises. The Nike “Swoosh,” and the Olympic Games’ interlocking Olympic Rings, for instance, have become inextricably associated with the products they represent. Recently, a new logo has been adopted for Stout’s identity and marketing. According to a brochure from Stout’s Marketing and Communications Department, this stylized “S” employs three shades of the color blue to “honor the past, present, and future of our university”; its parallel bands “reflect the inseparable tenets of applied learning, career focus, and collaboration” inherent in our identity and programming; and the ascending sweep of the “S” “reinforces the upward, onward... impact” of our larger Stout community. (Incidentally, we noticed that Alex’s cover design nicely echoes this new logo.)

The tenets suggested by this logo also represent the work we aim to publish in the *Journal of Student Research*. The articles featured here represent how our student researchers have turned their interests into contributions to the larger academic community. These students can be justifiably proud of their work and the contributions they have made. We value the “upward, onward” impact of all our student researchers.

We are thankful for the support the JSR has received from so many corners of our campus community. We thank the Office of Research and Sponsored Programs staff, Anne Hoeltke, Chela Cea, and Jeff Bates, for their support and guidance, helping the JSR reflect the ideals of student research; thanks to the UW-Stout Foundation for its generous funding of research at UW-Stout, some of which appears here. Thanks also to Dr. Charles Lume, who arranged for the juried art selections included in the JSR, to cover artist Alex Redetzke, to Chad Nyseth and the Graphic Communications Practicum, who were responsible for production; and to Dr. Joleen Hanson’s Editing Processes and Practices class.

We are pleased to present Volume XXI of the *Journal of Student Research*. Maybe not a “Swoosh,” but definitely an upward sweep of student achievement.

Executive Editorial Board

Anne Hoeltke

Director: Office of Research and Sponsored Programs

Peter E. Reim

Editor-in-Chief

Faculty Reviewers

Julia Chapman

Biology

Kevin Doll

Counseling, Rehabilitation & Human Services

Keith Gilland

Biology

Courtney Juelich

Social Science

Matt Kuchta

Chemistry/Physics

Kevin Hynes

Counseling, Rehabilitation & Human Services

Candice Maier

Counseling, Rehabilitation & Human Services

Marlann Patterson

Chemistry & Physics

Marcia Miller-Rodeberg

Chemistry & Physics

Seim, David

Social Science

Art Reviewer

Charles Lume
Art and Art History

Cover Design

Alex Redetzke
Graphic Design student

Layout and Printing

Chad Nyseth
Graphic Communications (GCOM) Program
UW-Stout Operations & Management Department

Brooks Erickson, Julia Anderson, and Courtney Schultz
Graphic Communications Practicum (GCOM-443)

Support

Stout University Foundation proudly supports undergraduate student research at UW-Stout. From its inception, UW-Stout has focused on applied learning to inspire students. Research projects enable undergraduate students to not only contribute valuable, new information to their field of study, but the lessons learned throughout the process impact them both professionally and personally. Students develop a keen sense of pride and accomplishment, knowing their education, innovation and hard work made a real impact. Stout University Foundation has contributed over \$150,000 in support of student research projects since 2013.



Minds@UW

The *Journal of Student Research* is searchable through Minds@UW; use this link: <https://minds.wisconsin.edu/handle/1793/83824>, or scan this QR code:



Table of Contents

SENIORS

Tamarack Restoration in a Wetland Reserve Property: Comparison with a Natural Reference Site..... 9

Kyle Baemmert and Christopher Jones
Faculty Advisors: Dr. Amanda Little and Dr. Keith Gilland

Exploring Family Dynamics, Mental Health, and Well-Being Among College Students with Foster Care Histories 19

Heather Dickrell
Faculty Advisor: Dr. Candice Maier

Impact of Personal Care Products on Tensile Strength and Structure of Hair 31

Jordan Kunze
Faculty Advisor: Dr. Matthew Ray

Rare Vascular and Bryophyte Plant Survey: Diversity within the Devil's Punchbowl 55

Britney Serafina
Faculty Advisor: Dr. Amanda Little

Black Robes: God's Patriots that Prepared America for Independence 67

DJ Walker
Faculty Advisor: Dr. Christopher Marshall

FINE ART SUBMISSIONS

For Its Season 79

Lauren Dillinger
Mentors: Tamara Brantmeier & Darren Tesar

Dividing the Day..... 85

Carley Holzem
Mentors: Kate Maury and Darren Tesar

Glove Tips & Chimp Pits..... 89

Brodie Spolar
Mentors: Mary Climes

Table of Contents (con't)

The strewn evidence meant something 95

Zach Zajda
Mentors: Daniel Atyim & Morgan Barrie

Tamarack Restoration in a Wetland Reserve Property: Comparison with a Natural Reference Site

Kyle Baemert and Christopher Jones¹

Senior, B.S. Environmental Science

Faculty Advisors: Dr. Amanda Little and Dr. Keith Gilland

Abstract

Wetlands are important ecosystems with high levels of productivity, biodiversity, and provision of ecosystem services. Recently, wetlands have become a focal point for ecological restoration; however, it is difficult to return a site to its former state once it has become disturbed. Certain tree species like tamarack (*Larix laricina* Du Roi) can struggle to re-establish. Information gathered from monitoring active tamarack restoration sites can refine current strategies and better inform re-establishment efforts. In this study, we compared a planted tamarack stand in a restored wetland enrolled in the Natural Resources Conservation Service (NRCS) Wetland Reserve Program (Downsville Wetland) to a stand of naturally established tamaracks (Muddy Creek Wildlife Area). We expected the Downsville Wetland to have a more homogenous stand structure than Muddy Creek, and that Muddy Creek would have smaller individuals, indicating recruitment to the population. The distribution of tamarack size was wider at Muddy Creek and Muddy Creek had greater species diversity. Consistent standing water throughout Muddy Creek had a negative relationship with tamarack size. Both sites had few individuals with a diameter-at-breast-height (DBH) under 5 cm, which indicates low recruitment. Further monitoring is required to more accurately draw conclusions about each stand's recruitment rate. Restoration in any context takes time and continued human influences at the Downsville Wetland could impact the restoration timeline. Although the Downsville Wetland does not yet resemble a natural stand like Muddy Creek, its restoration is still worthwhile because it provides many ecosystem services.

Keywords: tamarack, *Larix laricina*, wetlands, restoration, Wetland Reserve Program

Introduction

Wetlands have declined globally and domestically primarily due to human interference, such as draining, filling, and rerouting the flow of water (Dhal, 1990). Prior to European colonization, it is estimated the United States had nearly 392 million acres of wetlands (Dhal, 1990). In 200 years, from 1780 to 1980, the lower 48 states lost 53% of their wetlands, leaving only 274 million acres intact (Dhal, 1990). European settlers believed wetlands to be an obstacle to productive land use and

¹ Christopher Jones is a recipient of a student research grant from UIW-Stout's Office of Research and Sponsored Programs, funded by the Stout University Foundation (Editor).

drained wetlands to make the land "productive". Today, the importance of wetlands is better understood. Wetlands provide many ecosystem services, including fish and wildlife habitat, protection from shoreline erosion, maintenance of groundwater supply, floodwater abatement, sediment trapping, and improving water quality (Dhal, 1990).

As a result of their importance, wetlands have become a focal point for ecological restorative efforts. Unfortunately, a restored wetland is often considered not as high quality as a natural one because they tend to have lower biodiversity and lack similar function (Whigham, 1999). Both issues can stem from the fact that restoration projects are often never fully completed or end in failure (Whigham, 1999). As a result, it may be most beneficial to focus on restoring a few key elements or species of a wetland and letting nature take its course. One such key species vital for the succession of bogs to forests is the tamarack (*Larix laricina* Du Roi) (Duncan, 1954). The tamarack is unique in its ability to colonize sedge mat or sphagnum stages of bogs and through that colonization the site is prepared for more valuable tree species to move in (Duncan, 1954). Therefore, assisting in the reintroduction of tamaracks on a degraded site can restart the successional clock, setting up the site for succession from a bog in either a sedge mat or sphagnum stage to a forest succession, which will provide decades of natural transformations (Duncan, 1954).

Baseline data on existing vegetation and abiotic conditions such as wetland hydrology and light availability can help people make more informed decisions regarding tamarack restoration. The level of soil moisture is crucial to tamarack survival. Tamaracks are typically found in moist—but not saturated—areas and prefer a lower water table than black spruce (Evans et al., 2016). This could explain why tamaracks are often observed growing on top of hummocks (Evans et al., 2016). Although tamaracks are usually found in wetlands with saturated soil, they tend to prefer well-drained soils (Farrar, 1995). Knowing the depth of the water table across a site can help determine the most suitable place for tamaracks to live because they prefer a deeper water table (Evans et al., 2016). Hydrology can be measured by installing water table wells in key locations throughout the site (Miletti et al., 2005). The existing plant community can potentially affect the competitive environment tamaracks experience during establishment. Light availability is one of the most important abiotic factors to the survival of tamaracks because tamaracks are shade-intolerant (Evans et al., 2016). Tamaracks create shade in their understory allowing for shade tolerant species such as red maple (*Acer rubrum*) to establish and eventually overtop the tamaracks (Miletti et al., 2005), which is how the transformation from bog to forests initiates.

There is a careful balance between the positive effects tamaracks can have on wildlife and the negative effects wildlife can have on the reintroduction of tamaracks. Tamaracks themselves offer food and habitat for birds and small mammals such as the red squirrel, American red crossbill, red backed vole, white footed mouse, and shrews (Duncan, 1954). While white-tailed deer do not generally browse on tamaracks, their presence alone can introduce mechanical damage to tamarack saplings. Mechanical damage in this sense can be defined as the trampling or the breaking of the hypocotyl by deer walking through the area (Duncan, 1954) or when white tails mark their territory via rubbing their antlers on the trunks of young tamaracks.

We compared the structure of a planted tamarack stand at a wetland

restoration to a natural tamarack stand found in a State Natural Area. The primary purpose of our study was to determine if the tamaracks planted at the Downsville Wetland are recruiting and how their size and structure compares to a local natural tamarack stand. We also investigated the relationship between tamarack size and water depth at Muddy Creek to examine how hydrology may be influencing tamarack establishment. We hypothesized that (H1) the planted stand would have a more homogenous size-class structure than the natural stand, and (H2) the natural stand would have a greater number of non-tamarack woody individuals. Based on the claims of Evans and Farrar, we hypothesize that (H3) water depth will have a negative relationship with tamarack size (Evans et al., 2016; Farrar, 1995).

Methods

Study Sites

The restored tamarack stand is part of a generational farm located near Downsville, WI (44.729267, -91.956360), and is now owned by Bud Kadinger. The site was a natural tamarack bog in the late 1960's and early 1970's. Shortly thereafter, cattle began grazing the site and, as a result of root damage and soil compaction, the tamarack bog died out by the 1980's. Around 2015, the site was enrolled in the NRCS Wetland Reserve Program. The application was accepted in 2016, and soon after, the NRCS began replanting tamaracks. In 2018 the NRCS added to the restoration effort by constructing a dam and weir to restore historic hydrology (Bud Kadinger, personal communication). Today, the site consists of an open water aquatic bed and sedge meadow.

The natural tamarack stand is located at Muddy Creek Sedge Meadow State Natural Area (195 acres), near Elk Mound, WI (44.888206, -91.753026). The property is owned by the Wisconsin DNR and consists of high-quality sedge meadow with an understory of poison sumac (*Toxicodendron vernix*) and royal fern (*Osmunda regalis*). The Wisconsin DNR claims this site is a "transitional zone" which contains species found in both northern and southern sedge meadow communities (Wisconsin Department of Natural Resources, n.d.).

Data Collection

Slightly different data collection methods were used for the two sites to better accommodate the differences in area and tamarack density. The data collected at both sites include tamarack size (DBH), the count of other woody individuals in the plot, the count of dead tamaracks, the count of tamaracks in each DBH size class (< 1 cm, 1-2 cm, > 2 cm for the Downsville Wetland and < 2 cm and > 2 cm at the Muddy Creek site), the count of tamaracks with cones, and presence or absence of deer rubs on all trees in the plots.

Data from the Downsville Wetland was collected from 20 plots spread across 5 transects. Each plot had a radius of 5 m and was spaced every 30 m along the transect (Figure 1). The transects were systematically established prior to sampling using Google Earth Pro. They ran parallel North to South spaced 25 m apart, and their length ranged between 75 m and 256 m. We made use of the point-center-

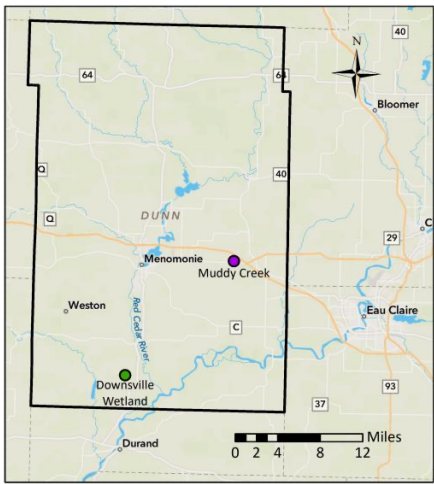


Figure 1: Approximate locations of Downsville Wetland and Muddy Creek within Dunn County, Wisconsin.

quarter method in each plot, measuring the size of the center tamarack and the four nearest tamaracks in each of the cardinal directions. The number of other woody species present was counted in the same 5-m radius plot.

At Muddy Creek, data was collected from twenty 10 m radius representative plots (Figure 2). Plots were chosen based on the presence of at least one tamarack, and the number of other species in the plot were counted in a 3 m radius around the center tamarack. We measured the size of all tamaracks in the plot and recorded water depth near the plot center.

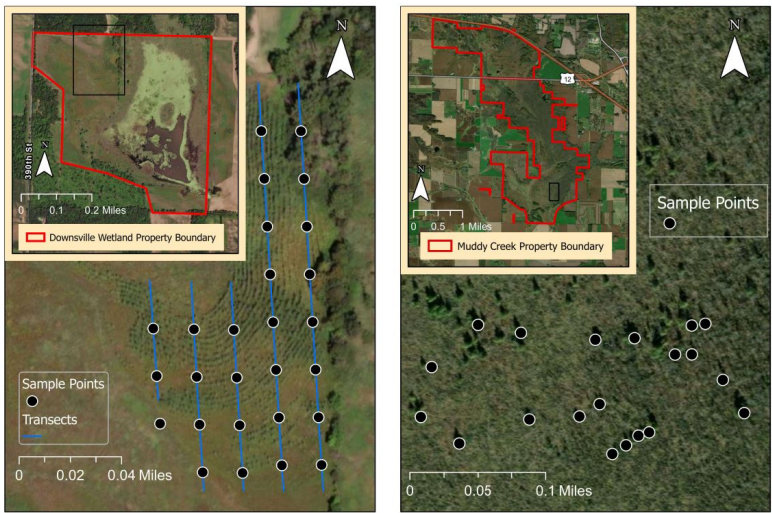


Figure 2: Site maps showing sampling points and property boundaries (red outlines) for each site. Property boundary maps also show location of sampling on the property (black outlines). (Left: Downsville Wetland, Right: Muddy Creek).

Data Analysis

The density of tamaracks and other woody species was calculated in stems per square meter for each plot. A scatter plot was made to show the relationship between water depth and tamarack size. Spearman's rank correlation was used to assess the relationship between tamarack size and water depth at Muddy Creek. A two-sample t-test was used to compare mean non-tamarack stem densities at Downsville Wetland and Muddy Creek.

Results

A greater number of tamaracks was measured at the planted site in Downsville, but these trees were, on average, smaller in diameter than the trees at Muddy Creek. The DBH of 217 tamaracks was measured in the planted stand in Downsville and 58 tamaracks at Muddy Creek. The mean DBH was 6.41 cm (+/- 2.39 SD) at the planted stand, 19.49 cm (+/- 9.57 SD) at the natural stand, and the median DBH was 6.3 cm and 18.7 cm, respectively.

Table 1: Summary statistics of data collected at the planted Downsville site and the natural Muddy Creek site.

	Downsville	Muddy Creek
Mean DBH (S.D.) (cm)	6.41 (2.39)	19.49 (9.57)
Median DBH (cm)	6.3	18.7
Minimum DBH (cm)	1.3	4.9
Maximum DBH (cm)	11.6	51.9
DBH range (cm)	10.3	47
Stem count (<1 cm)	0	0
Stem count (1-2 cm)	7	1
Stem count (>2 cm)	210	57
Total stem count	217	58
Stem count with cones	196	58
Dead stem count	0	2
Mean count of non-tamarack woody species (S.D.)	4.05 (5.77)	23.85 (9.88)
Mean standing water depth (S.D.) (cm)		10.37 (2.14)

The range of size for individuals varied greatly between the two stands. The natural tamarack stand had a much wider range of DBH measurements (47cm) compared to the planted stand (10.3 cm, Table 1, Figure 3). Muddy Creek contained a small number of large trees while the Downsville Wetland showed a normal distribution centered around a much larger mean size (Figure 3).

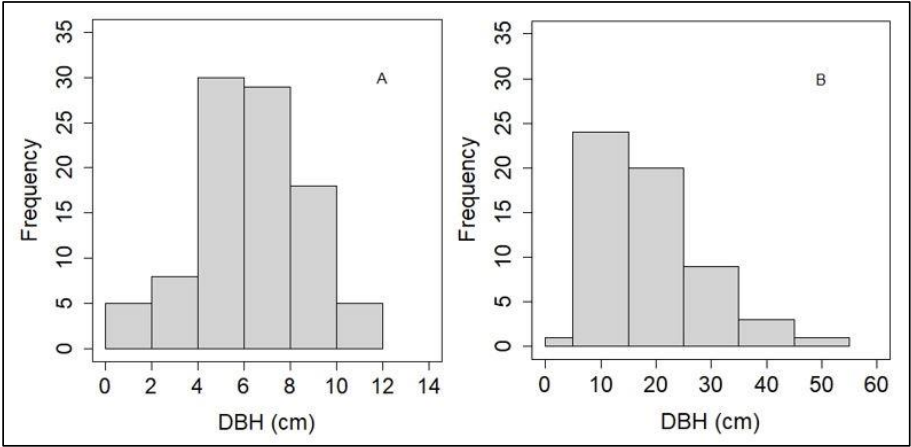


Figure 3: Size-class distribution (diameter at breast height, DBH, cm) of tamaracks at the Downsville Wetland (A) and the Muddy Creek Wildlife Area (B).

The planted tamarack stand had a much higher density of tamarack stems per plot than the natural stand ($t = 14.429$, $P < 0.001$, Figure 4). The average tamarack density at the Downsville Wetland was 0.138 stems/m² (+/- 0.039 SD) while the average tamarack density at Muddy Creek was 0.009 stems/m² (+/- 0.006 SD).

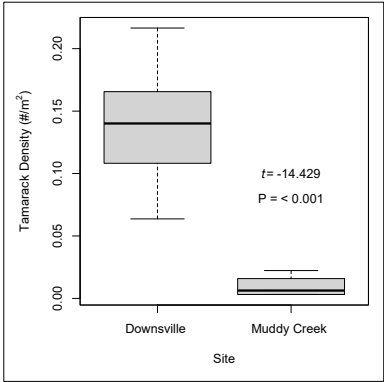


Figure 4: Comparison of tamarack density (stems/m²) between the two sites using a two sample-t-test ($t = -14.429$, $P < 0.001$).

The density and composition of non-tamarack woody species found in the understory differed between the two sites. The understory at the Downsville Wetland was just starting to develop and contained some red osier dogwood (*Cornus sericea*) and willow (*Salix spp.*). In stark contrast, the understory at Muddy Creek was quite robust and contained some red osier dogwood and willow, but was primarily poison sumac (*Toxicodendron vernix*) and alder (*Alnus spp.*). Sample plots located at Muddy Creek had a significantly higher density of stems from other woody species than the sample plots located at the Downsville Wetland ($t = -9.914$, $P < 0.001$, Figure 5). The mean density of other woody species at Muddy Creek was 0.844 stems/m²

(+/- 0.350 SD) while the mean density of other woody species at the Downsville Wetland was 0.052 stems/m² (+/- 0.073 SD; Table 1).

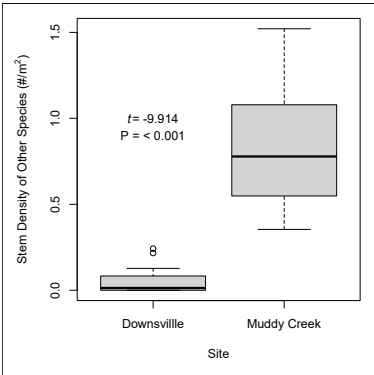


Figure 5: Comparison of the non-tamarack woody species density (stems/m²) between sites using a two-sample t-test ($t = -9.914$, $P < 0.001$).

Muddy Creek had standing water throughout the site while there was no surface water in the tamarack plots at the Downsville Wetland. The average standing water depth at Muddy Creek was 10.37 cm (Table 1). We observed a negative relationship between water depth and average tamarack density at Muddy Creek, although the correlation was non-significant ($r = -0.286$, $P = 0.221$, Figure 6).

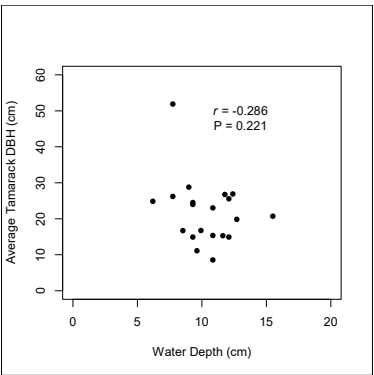


Figure 6: Relationship between the average tamarack DBH (cm) and water depth (cm) ($r = -0.286$, $P = 0.221$) at the Muddy Creek site.

Both sites had similar reproductive capabilities and deer utilization. About 90% of the tamaracks observed at the Downsville Wetland had cones, as compared to 100% at Muddy Creek. Meanwhile, 30% of the plots sampled at the Downsville Wetland had at least one individual present in the plot bearing a deer rub compared to 10% of the plots sampled at Muddy Creek.

Discussion

Our study revealed differences between the planted tamarack stand at the Downsville Wetland and the natural tamarack stand at Muddy Creek State Natural Area. Muddy Creek plots were densely vegetated, with an understory made up of alder (*Alnus sp.*) and poison sumac (*Toxicodendron vernix*), and with codominance in the overstory between black ash (*Fraxinus nigra*) and tamarack. Tamarack density at the site in Downsville was greater. It is likely the NRCS planted tamarack saplings densely because they knew not many would survive the juvenile stage. The mass planting of saplings could increase the chances for successful re-establishment. The plots were otherwise mostly depauperate of non-tamarack woody species. The lack of non-tamarack woody species could be related to the site's previous agricultural use. Lastly, Muddy Creek had consistent standing water throughout the site, whereas the Downsville Wetland had no observable standing water. Although non-significant, our data hinted that tamarack size and water level may have a negative relationship, which is consistent with other studies (Evans et al., 2016; Farrar, 1995).

The microtopography of each site was quite different. Muddy Creek had hummock-hollow microtopography, with tamaracks growing atop the hummocks and standing water in the surrounding hollows. The Downsville Wetland site was flat, without any noticeable hummock-hollow microtopography because the tamaracks there were planted in an old crop field. Mechanically reproducing hummock-hollow microtopography has shown to increase the recruitment of trees species faster than not doing anything on sites that have lost their microtopography (Filicetti et al., 2019).

Overall, the distribution of tamarack size was narrower at the Downsville Wetland than at Muddy Creek, likely due to the young nature of the Downsville Wetland planting compared to the naturally existing forest at Muddy Creek. As hypothesized, the planted tamarack stand at the Downsville Wetland was more consistent in size compared to the natural tamarack stand at Muddy Creek. Additionally, Muddy Creek had very few individuals with a DBH less than 5 cm, which may indicate poor recruitment, despite the ubiquitous presence of cones in all sample plots. The Downsville Wetland did have a much higher count of smaller individuals, which is likely due to them not having grown much since their initial planting 7 years ago. Therefore, the number of individuals with a DBH less than 5 cm may be a poor indicator of recruitment. About 90% of the measured tamarack at the Downsville Wetland had cones, which indicates to us that they have reached reproductive maturity and are capable of recruiting. Our initial observations indicate that the stand has yet to start recruiting because only about 5% of all measured tamaracks had a DBH less than 2 cm. Further inventory and future comparison to our baseline data will be needed to accurately determine whether the stand is recruiting or not.

Our results align with the existing literature that tamaracks are early successional species that colonize the edges of wet habitats. Even though tamaracks prefer drier soils (Farrar, 1995), they are often associated with wetlands because they cannot compete with other species, such as black spruce (*Picea mariana*), on drier soils. The density of other species in the understory at Muddy Creek may shade out any potential tamarack recruits and could be why the tamaracks are only seen as

part of the overstory at Muddy Creek. This suggests that Muddy Creek has moved beyond the time of tamarack dominance as the tamaracks have already facilitated the establishment of shade tolerant species that are gaining dominance instead (Duncan, 1954; Miletti et al., 2005). Muddy Creek could be an example of what the Downsville Wetland could look like as it eventually transitions to a shade tolerant forest.

This study also brings up the question of the goals of ecological restoration. Were the goals of the Downsville Wetland restoration to recreate a system like the Muddy Creek site, or to create a functional wetland that provides lost ecosystem services? If the purpose was to recreate a site like Muddy Creek, then the restoration at Downsville Wetland was unsuccessful due to the lack of proper hydrology and the current community composition. If the purpose of restoration was to recreate a functional wetland, then the restoration was successful because it provides wildlife habitat, as evidenced by the numerous bird nests and buck rubs observed.

Overall, our study shows that tamarack restoration takes time and that continued data collection of the restoration can further inform the restoration process. The Downsville Wetland will require many years of natural development after restoration activities before it can be considered an equivalent to a reference site like Muddy Creek. The restoration at the Downsville Wetland may be improved by creating hummock-hollow topography to improve tamarack regeneration (Filicetti et al., 2019). It may be worthwhile to research if hummock-hollow topography ever existed at the Downsville Wetland. Continued human activity (e.g., mowing and potentially other management activities) at the Downsville Wetland may cause it to always be substantially different than that of a natural tamarack stand. Even if the Downsville Wetland tamarack stand fails to recruit, the current individuals could persist, and the attempted restoration is not a failure. Currently, the site is frequented by deer and many different species of waterfowl, and this attraction may be due to the combination of restored hydrology and the return of the tamarack stand.

References

- Dahl, T. E. (1990). Wetlands losses in the United States, 1780's to 1980's. U.S. Dept. of the Interior, Fish and Wildlife Service.
- Duncan, D. P. (1954). A Study of Some of the Factors Affecting the Natural Regeneration of Tamarack (*Larix Laricina*) in Minnesota. *Ecology*, 35(4), 498–521. <https://doi.org/10.2307/1931040>.
- Evans, C., DeSotle, R., Mattilio, C., Yankowsky, E., Chenaille, A.-A., & Whiston, A. (2016). A Fine-scale Examination of *Larix laricina* and *Picea mariana* Abundances along Abiotic Gradients in an Adirondack Peatland. *Northeastern Naturalist*, 23(3), 420–433.
- Farrar, J. L. (1995). *Trees of the Northern United States and Canada*. Iowa State University Press.
- Filicetti, A. T., Cody, M., & Nielsen, S. E. (2019). Caribou Conservation: Restoring Trees on Seismic Lines in Alberta, Canada. *Forests (19994907)*, 10(2), 185. <https://doi.org/10.3390/f10020185>.
- Miletti, T. E., Carlyle, C. N., Picard, C. R., Mulac, K. M., Landaw, A., & Fraser, L. H. (2005). Hydrology, water chemistry, and vegetation characteristics of a Tamarack Bog in Bath Township, Ohio: Towards restoration and enhancement (1). *The Ohio Journal of Science*, 105(2), 21–31.
- Whigham, D. F. (1999). Ecological issues related to wetland preservation, restoration, creation, and assessment. *Science of The Total Environment*, 240(1–3), 31–40. [https://doi.org/10.1016/S0048-9697\(99\)00321-6](https://doi.org/10.1016/S0048-9697(99)00321-6).
- Wisconsin Department of Natural Resources. (n.d.). *Muddy Creek Wildlife Area* || Wisconsin DNR. Wisconsin Department of Natural Resources. Retrieved January 8, 2023, from <https://dnr.wisconsin.gov/topic/Lands/WildlifeAreas/muddycreek.html>.

Exploring Family Dynamics, Mental Health, and Well-Being Among College Students with Foster Care Histories

Heather Dickrell¹

Senior, Human Development and Family Studies

Advisor: Dr. Candice Maier

Abstract

The impact of a foster family environment on mental health and well-being has been studied; however, less is known regarding the experiences of foster youth who have transitioned out of foster care and are now pursuing post-secondary education. This study aimed to explore the experiences of college students with foster care histories, specifically their foster family environment, mental health and well-being. Using a Qualtrics survey, we gathered data from 56 former foster youth from the United States. Results demonstrated an array of experiences surrounding foster family support, dynamics, and mental health. Overall, we found that our sample reported more mild symptoms of anxiety compared to more severe levels which are often found in other research with this population. Suggestions for future research are discussed.

Keywords: foster college youth, family dynamics, mental health, well-being

Introduction

Family dynamics and mental health are crucial elements in the transition to post-secondary education for former foster youth. Although research has been conducted on these variables (Chateauneuf et al., 2017; Havlicek et al., 2012; Miller et al., 2020), limited research has looked at these constructs among former foster youth who are in college or are transitioning to college. Foster care youth are particularly at high risk of mental and physical health problems (Havlicek et al., 2013; Stone & Jackson, 2021), learning and education barriers (Piel, 2018), and risk of sex trafficking (Selig, 2018). Additionally, disproportionate placement of foster youth of color has been a long-standing issue within child welfare (Cross, 2008). Studies have shown that foster youth who pursue education after high school and achieve academic success need additional support at the individual, family, and community levels during this time (Franco & Durdella, 2018; Hines et al., 2005; Miller et al., 2020).

Previous studies have documented attachment styles of college students attending four-year universities with foster care histories (Okpych & Gray, 2021) and evaluated the impact of policy and programming on the transition to adulthood for foster youth (Geiger & Okpych, 2022; Okpych & Courtney, 2020). However, few studies have explored the perceptions of former foster youth who have transitioned

¹ Heather Dickrell is a McNair Scholar. Ms. Dickrell also is a recipient of a student research grant from UW-Stout's Office of Research and Sponsored Programs, funded by the Stout University Foundation (Editor).

to post-secondary education (i.e., vocational/technical school, four-year university, etc.) regarding their foster family dynamics and mental health. Given the lack of primary data on this population during this pivotal time in their lives, it seems important to highlight these experiences to get a more complete picture of their experiences, including perceptions of their foster family environment, level of support, as well as their own mental health. Thus, the purpose of this study was to explore the experiences of this population in hopes that our findings shed light on the unique needs of college students with foster care histories.

Literature Review

Former foster youth have a more challenging time transitioning from the foster care system to post-high school education than peers who were not in foster care (Franco & Durdella, 2018). Foster youth who are transitioning out of foster care are also at greater risk for experiencing mental health disorders such as major depression, anxiety, post-traumatic stress disorder, and alcohol and substance abuse (Courtney et al., 2001; Havlicek et al., 2013; Stone & Jackson, 2021). Specifically, foster youth are two to four times more likely to suffer from lifetime and/or past year mental health disorders compared to non-foster youth in the general population at the ages of 17-18 (Havlick et al., 2013). Factors such as family support, family dynamics, and mental health and well-being can affect the experiences of foster youth who transition to college and have a drastic impact on whether or not they stay in college (Chateauneuf et al., 2017; Miller et al., 2020; Waid et al., 2016). Further, a lack of services, a history of mental illnesses within the family, and the type of placement also impact the experiences of former foster youth (Waid et al., 2016). While there is literature to support these links and risk factors to former foster youths' success in college, there is a need for more studies looking at the experiences of former foster youth who have transitioned to post-secondary education.

Family Support

Up until recently, the field often tended to blame parents as opposed to engaging them as a resource for positive change (Cross, 2008). Relationships between foster youth, either current or former, and their biological or foster parents are often complex and can have a significant impact on the individual. For instance, the relationship between the foster parents and biological parents (if possible and if biological parents are alive) is one of the most important relationships for a child in foster care (Chateauneuf et al., 2017). Foster parents' and biological parents' relationship can impact the child's development, well-being, and future relationships which supports the need for healthy parental relationships (Chateauneuf et al., 2017). Foster parents also share this importance with foster youth but may find it difficult to maintain relationships with biological parents themselves if they have one. Chateauneuf and colleagues (2017) found there are multiple factors that may affect the relationship between the birth parents and foster parents, including cultural backgrounds, household rules, education, lifestyles, socioeconomic status, and child raising practices (Chateauneuf et al., 2017).

The type of placement and length can change the stability of care; for instance, kinship foster care placement provides youth with more stability and a

greater chance of sibling co-placement (Franco & Durdella, 2018; Waid et al., 2016). By placing youth with family, positive family dynamics within their biological family occur and youth can build relationships with family members. It should be noted that while not every relationship will have the same outcome, biological family relationships and kin foster care placement can increase the chance of a positive family dynamic (Waid et al., 2016). More studies found an increase in reconnection with biological family members after aging out of the foster care system (Courtney et al., 2007; Franco & Durdella, 2018), although it should be noted that foster youth may seek connection with biological family at any point during foster care regardless of whether this is supported by the foster care system or foster parents. In contrast, one study found that conflict in a household with biological family members can worsen mental health symptoms (Stone & Jackson, 2021). Regardless, family dynamics that are high in conflict and low in cohesion and adaptability produce an environment that places the youth at a greater risk for mental health problems, difficulties, and symptoms. (Stone & Jackson, 2021).

As studies have shown (Kearney et al., 2019; Miller et al., 2020; Selig, 2018; Stone & Jackson, 2021), family beliefs can influence the experience youth have while in foster care. For instance, LGBTQ youth are especially at risk of being harmed by foster families who are not affirming and accepting of their identity (Lorthridge et al., 2018). LGBTQ youth are seven times more likely to be removed from their home than heterosexual youth, and five times more likely to have a negative foster care experience (Lorthridge et al., 2018). In a study conducted in New York, 78% of LGBTQ foster youth run away due to hostility toward their sexual orientation or gender identity (Lorthridge et al., 2018). This alarming percentage demonstrates the harm of homophobia and heteronormativity and the need for great support among LGBTQ foster youth (Lorthridge et al., 2018).

Additionally, the lack of similarity in family dynamics and placement types makes it hard to determine the best practice to implement healthy, stable, and supportive family dynamics for youth in foster care. Even after being taken away from their biological parents, the "Midwest Study" found 94 percent of participants felt somewhat close to one biological family member and 77 percent felt very close during the transition age (Courtney et al., 2007), while another study found only a small portion of individuals kept in contact with their biological family members (Hines, et al., 2005). The mixed findings suggest biological relationships can be complex for foster youth to navigate but have the potential to help support healthy relationships among foster youth and biological family members (Courtney et al., 2007; Hines et al., 2005). Suggestions for introducing this relationship include foster parents asking at a younger age if foster youth are interested in knowing their biological family, considering if it is in the best interest for their future, and ensuring that the type of placement will allow for biological relationships to occur (Courtney et al., 2007; Fargas-Malet & McSherry, 2021; Kearney, 2019; Stone & Jackson, 2021).

High School to College Transition

Studies have suggested that former and current foster youth need targeted support in high school in order to obtain successful educational achievement in college (Hines et al., 2005). Franco and Durdella (2018) found that just over

half of foster youth graduate high school in their lifetime (compared to 83% of non-foster peers), while 3-11% of foster youth earn a college degree (Franco & Durdella, 2018). One of the challenges cited by former foster youth pursuing higher education regarding support is the assumption that college-aged youth are adults and independent. While it should be noted that all emerging adults need support when transitioning to post-secondary education, studies show that former foster youth need additional supports catered to their specific needs when starting post-secondary education (Miller et al, 2020). Failure to obtain support can lead to former foster college students feeling isolated, which can result in these students dropping out, enrolling in fewer credits, and obtaining lower GPAs compared to their non-foster peers (Miller et al., 2020).

Kearney (2019) found both support as defined by youth and traditional family support are among important factors in foster college students' success. Family members are vital support systems and can help youth achieve their academic goals (Franco & Durdella, 2018). Although there are former foster youth who succeed in post high school education, this population is least likely to attend college (Hines et al., 2005; Kearney, 2019). The benefits that come from attending post-high school education, such as financial growth and developmental skills learned, could benefit foster youth greatly and assist with the transition to adulthood (Hines, et al., 2005).

Furthermore, the summer between high school and post-secondary education (e.g., college) is a critical transition period, and yet responsibility for assuring foster youth have support during this time is currently not required or mandated for either high school or university and college systems. Programs such as First Star, a national charity launched in 2011, provide high school youth in foster care with tools and support for successfully transitioning to higher education and the workforce; however, only those foster youth with connections to such resources through their foster families, schools, etc. have access. Thus, the gap between former foster youth needs and available resources must be addressed, such as being able to stay part of the foster care system past the age of 18 and maintaining stability in care and type of placement (Franco & Durdella, 2018).

Mental Health and Well-Being

The few studies on foster youth transitioning out of the foster care system and their mental health and well-being (Havlicek et al., 2012; Miller et al., 2020; Stone & Jackson, 2021) shows there is an urgent need to assist and implement ways to help this population. The use of mental health services has been found to decline as one ages but the rate of mental health disorders is two to four times greater among foster youth than their peers who are also transitioning into adulthood (Courtney et al., 2007; Havelick et al., 2013). A study exploring college students' identity among individuals with foster care histories and mental health challenges stated mental health challenges among youth make the transition more difficult (Miller et al., 2020) as well as their identity development, academic performance, and college retention (Miller et al., 2020). Miller and colleagues (2020) found four themes among foster youth that affected mental health and well-being among former foster college-aged youth, including feelings of otherness, stacking stressors, self-reliance versus support-seeking, and improving student experiences on campus.

Study Purpose

Given the gaps in the literature on the perceptions of college foster youth regarding their foster family dynamics and mental health, this study sought to explore the experiences of post-secondary students with foster care histories; specifically, perceptions of foster family dynamics, mental health (i.e., anxiety), and well-being. The research questions for this study were: (1) What are the experiences of former foster college youth with regard to their foster family dynamics and (2) What are the experiences of former foster college youth with regard to their mental health and well-being?

Method

Participant Recruitment and Description

Participants were former foster youth who were either currently enrolled in post-high school education or had previously attended post-high school education. Additional criteria for inclusion in the study were that participants had to be at least 18 years old and part of the foster care system as a child or adolescent. Upon receiving Institutional Review Board (IRB #202204149) approval, data for this study were collected using a variety of methods, including (1) social media (e.g., Fostering Youth Independence (FYI) Facebook page, and (2) emails to programs aimed at providing guidance and resources to former foster care youth within the University of Wisconsin System (i.e., Directors of Trio, Student Support Services, and Fostering Success Programs) as well as two large fostering/adoption organizations (Foster Nation and Children's Home Society and Family Services).

Of the 85 individuals who clicked the link and consented to participate, 56 clicked "yes" to a) being 18 years or older, b) currently enrolled or previously enrolled at a college, university, technical, vocational, or trade school, and c) having been in foster care as a child or adolescent, and thus were eligible to participate and completed the entire survey. Upon starting the survey, participants were presented with informed consent followed by a description of the study. If participants agreed to the terms and met the criteria, they were then provided with a series of Likert-scale questions, five open-ended questions, and demographic questions. At the end of the survey, a list of local and national resources for accessing mental health and support services was provided. Participants were provided with the opportunity to enter a drawing (on a separate survey not linked to their data) for one of 15 \$25 Amazon gift cards.

Procedures

First, data were exported from Qualtrics and downloaded to an Excel document with numeric and text responses. Data from the 85 participants who clicked on the survey link were then cleaned and all variables were screened for missing data and recorded to accommodate variations in the data and determine agreement in scale item values. Individuals who responded "no" to the first two questions were not included in the final sample. Individuals who did not respond to survey questions beyond the first eleven questions were deleted from the database ($n = 8$), resulting in a total sample of 56 participants.

Second, participants completed demographic questions after responding to an abbreviated version of the Family Environment Scale (FES; Moos & Moos, 1994), Generalized Anxiety Disorder Scale-7 (GAD-7; Spitzer et al., 2006), and an abbreviated version of the Positive Home Integration Scale (PHI; Wait et al., 2016).

Participants

Participants varied in age from 18 to 32 years, with an average of 22.3 years. Fifty percent of participants identified as female (n = 28), 48.2% identified as male (n = 27), and one participant preferred to self-describe (1.8%) listing as non-binary, transmasc, and two-spirit (see Table 1). The majority of participants identified as straight/heterosexual (80.4%), while 10.7% identified as bisexual, 5.4% as gay, and 1.8% preferred to self-describe. One participant (n = 1) did not respond to this question. Approximately 45% percent of participants identified as White while 39.3% of participants identified as Black/African American which fits with the over-representation of youth of color in the foster care system compared to foster families (Cross, 2008). In terms of highest degree or level of school completed, 35.7% were high school graduates, 23.2% attended some college, 16.1% attended some graduate school, 10.7% completed college, 7.1% completed some vocational/trade school, 3.6% completed vocational/trade school, and 3.6% completed some graduate school.

Participants represented diverse regions throughout the U.S. A majority of participants (62.5%) reported being from an urban area, 26.8% from a suburban area, and 10.7% from a rural area.

Characteristics	(M [SD] or %)
Gender	
Female	50.0% (n = 28)
Male	48.2% (n = 27)
Self-Describe:	1.8% (n = 1)
Age	22.34 [SD = 3.76]
Sexual Orientation	
Gay	5.4% (n = 3)
Straight/heterosexual	80.4% (n = 45)
Bisexual	10.7% (n = 6)
Self-Describe:	1.8% (n = 1)
Race/Ethnicity	
Black/African American	39.3% (n = 22)
White/Caucasian	44.6% (n = 25)
Latinx	3.6% (n = 2)
South Asian/Indo-Pak	3.6% (n = 2)
East Asian	5.4% (n = 3)
Native American	1.8% (n = 1)
Biracial/multiracial	1.8% (n = 1)
Education	
High school graduate	35.7% (n = 20)
Some college	23.2% (n = 13)
Some vocational/trade school	7.1% (n = 4)
Vocational trade school	3.6% (n = 2)
College	10.7% (n = 6)
Some graduate school	3.6% (n = 2)
Graduate school	16.1% (n = 9)
Geographic Location	
Urban area	62.5% (n = 35)
Suburban area	26.8% (n = 15)
Rural area	10.7% (n = 6)

Table 1: Descriptive Statistics for Demographic Characteristics (N = 56).

Measures

Family Dynamics

Eleven questions were taken from the original 90-item Family Environment Scale (FES; Moos & Moos, 1994) which measured perceptions of family cohesion, expression, conflict, and independence. The items from this shortened 11-item measure were selected to reduce survey participant burnout. Participants responded to items using the Scale's Likert scale ("Strongly agree to "Strongly disagree"). Sample items included, "Family members really help and support one another," and "If there's a disagreement in our family, we try hard to smooth things over and keep the peace." Higher total mean scores indicated stronger agreement with the questions or prompts (see Table 2).

Scale Items	<i>M</i>	<i>SD</i>	Min.	Max.	<i>n</i>
Help support one another	3.82	1.11	1	5	56
Get nowhere with raising voice	2.55	1.19	1	5	56
Fight a lot in our family	3.16	1.30	1	5	56
Often criticize each other	2.89	1.31	1	5	56
Try to keep the peace	2.30	1.03	1	5	56
Get along really well	2.50	1.13	1	5	56
Sometimes throw things	3.13	1.36	1	5	56
Feeling of togetherness	2.32	1.08	1	5	56
Back each other up	2.46	1.08	1	5	56
Plenty of time and attention	2.64	1.03	1	5	56
Rarely become openly angry	2.87	1.25	1	5	56

Note. "5" = Strongly Agree, "1" = Strongly Disagree.
Note. Higher means indicated stronger agreement. Lower means indicated stronger disagreement.

Table 2: Descriptive Statistics of Family Environment Scale (N = 56).

Mental Health and Well-Being

Participants completed the Generalized Anxiety Disorder Scale (GAD-7; Spitzer et al., 2006) to assess mental health and well-being, specifically anxiety symptoms. The measure included items rated on a 4-point Likert scale starting at 0 (0 = "Not at all" to 1 = "Several days," 2 = "More than half," and 3 = "Nearly every day") to the question, "how often have you been bothered by the following problems?" and included statements like, "feeling nervous, anxious, or on the edge," and "not being able to stop or control worrying." Higher mean scores indicated higher overall anxiety, while lower mean scores indicated fewer symptoms (see Table 3). It is important to note that our sample was not clinical, and we therefore did not determine cutoff points or interpret scores in a traditional sense that one may use to determine whether a person meets the criteria for generalized anxiety disorder.

Scale Items	<i>M</i>	<i>SD</i>	Min.	Max.	<i>n</i>
Feeling nervous	1.14	.96	0	3	56
Not able to stop worrying	1.00	.95	0	3	56
Worrying too much	1.07	1.06	0	3	56
Trouble relaxing	1.14	1.02	0	3	56
Hard to sit still	0.89	.97	0	3	56
Easily annoyed	1.11	1.02	0	3	56
Something awful might happen	1.04	.97	0	3	56

Note. 0 = Not at all, 1 = Several days, 2 = More than half, 3 = Nearly every day
Note. Higher means indicated higher anxiety levels. Lower means lower anxiety levels.

Table 3: Descriptive Statistics of Generalized Anxiety Disorder-7 Scale (N = 56).

Foster Youth and Home Environment

The Positive Home Integration scale (PHI; Waid et al., 2016) was used to explore the experiences of foster youth in their home environment and relationships within the home. The original scale uses 9 items to measure positive home integration; however, to reduce participant burnout, a total of five open-ended questions were selected for this study. Example items included, "To what extent do you feel included in your (foster) family?" and "To what extent do you feel that you are involved in decision-making in your (foster) family?" Participants were encouraged to share as little or as much as they wanted and were provided with essay text boxes within the survey.

In addition, participants were asked who they identify as a supportive person in their life with options ranging from family member, friend, romantic or sexual partner.

Results

Overall, participants in our sample reported slightly more disagreement than agreement on survey items for the Family Environment Scale (FES), such as, "Try to keep the peace" and "Family togetherness." One outlier on this scale was the response to the prompt, "Family members really help and support one another" which was slightly more favorable toward a stronger agreement (M = 3.82, SD = 1.11). Two other items that veered slightly more toward the "neutral" category were "Family members sometimes get so angry they throw things" and "We fight a lot in our family." Participant responses ranged from 1 ("Strongly Disagree") to 5 ("Strongly Agree").

Second, we found that overall, participants reported scores that would be interpreted as more mild symptoms on the Generalized Anxiety Disorder Scale-7 (GAD-7). Specifically, a majority of participants responded "not at all" to being bothered and feeling "so restless that it is hard to sit still" (M = 0.89, SD = .97). The two highest mean scores calculated were for the prompts "feeling nervous, anxious, or on edge" and "trouble relaxing" which were 1.14 (SD = .96 and 1.02 respectively) indicating "several days" in the past two weeks they felt bothered.

Finally, we collected open-ended responses to The Positive Home Integration scale (PHI; Waid et al., 2016) and found a range of both favorable and less favorable responses in terms of the extent that participants felt included in their foster families, felt about their relationships with family members, and the extent to which former foster youth felt that their foster parent listened to them. Examples include the following:

"[...] just like every family we are dysfunctional in some way and considering all of us come from the foster system (foster parents included) we all have things that will set us off and it is constantly changing."

Another, less favorable example includes the following: "I get excluded even as a college student because my foster parents treat their biological children and grandchild better and do more things with them. Plus, my foster parents verbally berate me."

Discussion

Although we did not conduct comparative tests or analyses on our results, we did expect to find these from reports based on what we know in the literature about at-risk outcomes for former foster youth and the transition to post-secondary education pertaining to foster family environment and mental health. Specifically, studies have shown that family support/dynamics, and mental health symptoms can impact the academic and personal experiences (Chateauneuf et al., 2017; Miller et al., 2020; Waid et al., 2016).

It was unexpected to find that although the overall sample reported more mild symptoms and less severe symptoms on the GAD-7 scale, many participants responded with more disagreement and less favorability to items regarding their family environment. Open-ended responses provided a plethora of information regarding how supported one felt by their foster family, which is a critical element to feeling supported in post-secondary schooling (Chateauneuf et al., 2017). In contrast, youth who do not feel supported are at higher risk of not performing well in college (Hines et al., 2005). Additional support is vital for foster youth to perform at college standards (Okpych & Courtney, 2019; Okpych & Gray, 2021). Biological family support is important for success in higher education but sometimes can evoke more stress and conflict which may hinder their success (Okpych & Gray, 2021). Additionally, we found that foster youth experience some level of anxiety no matter their level of support.

Limitations and Future Directions

While attempts were made to recruit a diverse sample, there were some limitations. First, the data were collected from a mostly heterosexual (80.4%), gender binary (98.2%), and urban-residing population (62.5%). Thus, it is possible that data from a more LGBTQ and geographically diverse sample would illustrate more divergent or variant themes, as well as yield different mean scores. Further, we did not ask for the socioeconomic status of foster youth or their foster families. Future research should consider how social class and frequency (if any) of changes in foster family placement impact the experiences of foster families and foster youth.

While the researchers were able to capture experiences from a racially diverse sample, one limitation of the study was that we did not ask about the race/ethnicity of foster family members and parents. Future research should consider the ways in which racism impacts the fostering process as there is a long-standing history of racism in the foster care system, with a significant over-representation of Black and Native American populations in the foster and child welfare system (Cross, 2008).

Due to the monetary incentive provided in this study after the initial three weeks of data recruitment (\$25 Amazon gift cards), it is possible that participants were more motivated to participate compared to earlier within the data recruitment stage.

Conclusion

This study provides insight into the experiences of college students with foster care histories with regard to their foster family environment, perceptions of support, and mental health and well-being. Largely, responses from participants were less favorable when asked about their foster family environment. Participants' responses to mental health symptoms were more moderate compared with scores that may be interpreted as more severe. When former foster youth were asked with whom they could identify as support systems in their lives, the responses ranged from family members, friends, romantic or sexual partners, and extended family. We hope this study is acknowledged by educators, social service workers, family members (foster, chosen, biological), and others, to bring awareness to former foster youth and the factors that may hinder or help their education path.

References

- Chateauneuf, D., Turcotte, D., & Drapeau, S. (2017). The relationship between foster care families and birth families in a child welfare context: The determining factors. *Child & Family Social Work*, 2018(23), 71-79. <https://doi.org/10.1111/cfs.12385>.
- Cross, T. L. (2008). Disproportionality in child welfare. *Child Welfare*, 87(2), 11-20. <https://doi.org/0009-4021/2008/0208011-20>.
- Courtney, M.E., Dworksy, A., Ruth, G., Havlicek, J., Perez, A., & Keller, T. (2007). Midwest evaluation of the adult functioning of former foster youth: outcomes at age 21. *Chapin Hall Center for Children*.
- Fargas-Malet, M., & McSherry, D. (2021). The emotional nature of birth family relationships for care-experienced and adopted young people: A longitudinal perspective. *Journal of Family Issues*, 42(10), 2263-2288. <https://doi.org/10.1177/0192513X20978439>.
- Franco, J., & Durdella, N. (2018). The influence of social and family backgrounds on college transition experiences of foster youth. *New Directions for Community Colleges*, 184, 69-80. <https://doi.org/10.1002/cc.20293>.
- Geiger, J. M., & Okpych, N. J. (2022). Connected after care: Youth characteristics, policy, and programs associated with postsecondary education and employment for youth with foster care histories. *Child Maltreatment*, 27(4), 658-760. <https://doi.org/10.1177/10775595211034763>.
- Havlicek, J. R., Garcia, A. R., & Smith, D. C. (2012). Mental health and substance use disorders among foster youth transitioning to adulthood: Past research and future directions. *Children and Youth Services Review*, 35(2013), 194-203. <https://dx.doi.org/10.1016/j.childyouth.2012.10.003>.
- Hines, A. M., Merdinger, J., Wyatt, P. (2005). Former foster youth attending college: Resilience and the transition to young adulthood. *American Journal of Orthopsychiatry*, 75(3), 381-394. <https://doi.org/10.1037/0002-9432.75.3.381>.
- Kearney, K. S., Naifeh, Z., Hammer, T., & Clain, A. (2019). "Family" ties for foster alumni in college: An open systems consideration. *The Review of Higher Education*, 42(2), 793-824. <https://doi.org/10.1353/rhe.2019.0015>.
- Lorthridge, J., Evans, M., Heaton, L., Stevens, A., & Phillips, L. (2017) Strengthening family connection and support for youth in foster care who identify as LGBTQ: Findings from the PII-RISE evaluation. *Child Welfare*, 96(1), 53-78.
- Miller, R., Blakeslee, J., & Ison, C. (2020). Exploring college student identity among young people with foster care histories and mental health challenges. *Children and Youth Services Review*, 114. <https://doi.org/10.1016/j.childyouth.2020.104992>.
- Moos, R. H., & Moos, B. S. (1994). *Family Environment Scale manual* (3rd ed.). Consulting Psychologists Press.
- Okpych, N. J., & Courtney, M. E. (2020). The relationship between extended foster care and college outcomes for foster care alumni. *Journal of Public Child Welfare*, 14(2), 254-276. <https://doi.org/10.1080/15548732.2019.1608888>.
- Okpych, N. J., & Gray, L. A. (2021). Ties that bond and bridge: Exploring social capital among college students with foster care histories using a novel social network instrument (FC-Connects). *Innovative Higher Education*, 46, 683-705.

<https://doi.org/10.1007/s10755-021-09553-x>.

Piel, M. H. (2018). *New directions for community colleges: Challenges in the transition to higher education for foster care youth*. (pp. 21-28). Wiley Periodicals, Inc.

Selig, E. (2018). Statistically speaking: The overrepresentation of foster youth in sex trafficking. *Children's Legal Rights Journal*, 38(1), 84-87. <https://doi.org/131957610>.

Spitzer, R. L., Kroenke, K., Williams, J. B. W., & Lowe, B. (2006). A brief measure for assessing generalized anxiety disorder. *Archives of Internal Medicine*, 166, 1092-1097. <https://doi.org/10.1001/archinte.166.10.1092>.

Stone, K. J., & Jackson, Y. (2021). Linking foster family characteristics and mental health symptoms of youth in care. *Journal of Child and Family Studies*, 30, 2792-2807. <https://doi.org/10.1007/s10826-021-02107-x>.

Waid, J., Kothari, B. H., Bank, L., & McBeath, B. (2016). Foster care placement change: The role of family dynamics and household composition. *Children and Youth Services Review*, 68(2016), 44-50. <https://dx.doi.org/10.1016/j.childyouth.2016.06.024>.

Impact of Personal Care Products on Tensile Strength and Structure of Hair

Jordan Kunze¹

Senior, Applied Science: Industrial Chemistry

Faculty Advisor: Dr. Matthew Ray

Abstract

Currently, there is a lot of debate over hair products and the components within them. While sulfates and parabens have been the two most controversial components within hair products, there is very little public knowledge regarding how other chemical components can impact hair. The purpose of this research is to explore the three chemical components (citric acid, hydrogen peroxide, and sodium chloride) found in shampoo, and evaluate the impacts that each of these chemical components can have on hair. The impact of these chemicals will be quantified through testing changes and differences in the mass, tensile strength, and hair diameter. Based on the results of this study, it appears that DI water has a significant impact on hair, which impacts how clear the other results are. While the way each of these chemicals interacts with hair seems significant, further research needs to be done to get a clearer understanding of how the other chemical treatments impact hair and how significant the impacts are.

Introduction

The purpose of this study is to examine the impact that specific chemicals have on hair. The chemicals being studied are citric acid, hydrogen peroxide, and sodium chloride. These chemicals are commonly found in hair products such as shampoo, conditioner, and hair lighteners. To compare the impact that these chemicals have on hair, stress-strain analysis was completed on treatment groups as well as a control group that used DI water. DI water refers to deionized water, which is free of contaminants such as ions or minerals. This involved subjecting hair samples to a set treatment and completing a pull test on each treated hair to measure the force that it took to break the hair, as well as the amount that the length of the hair changes before it breaks. These measured values were then used to calculate stress and strain using the following equations:

$$\text{Stress} = \frac{\text{Break Force}}{\text{Cross Sectional Area}} \quad \text{Strain} = \frac{\text{Change in Length}}{\text{Original Length}}$$

The primary reason to study the impacts that these chemicals have on hair is to better understand the chemicals that are commonly used in hair products, as there

¹ Jordan Kunze is a member of the Honors College of UW-Stout, and a McNair Scholar. Ms. Kunze is also a recipient of a student research grant from UW-Stout's Office of Research and Sponsored Programs, funded by the Stout University Foundation (Editor).

is not currently a lot of published knowledge on this topic. By understanding these impacts, we can better inform people's decisions on what products to use based on the chemicals that are in them. For example, if one of the studied chemicals shows a strong negative impact on hair, understanding this impact may lead people to avoid products with this chemical.

The main chemicals of focus for this study are citric acid, sodium chloride, and hydrogen peroxide. While there does not appear to be published data on how these chemicals directly impact the mechanical properties of hair, there are anecdotal claims on the impacts that these chemicals have. According to multiple sources, citric acid can be beneficial to hair in multiple ways. The two main ways that citric acid benefits hair are by removing product buildup in hair making the hair appear brighter, and by lowering the pH of hair products to a pH that is better for hair. Some of these claims can be seen in sources such as anveya.com and other blogs. In the case of sodium chloride, the consensus appears to be that it is harmful to hair. There are a variety of explanations for why sodium chloride is harmful to hair, but the most common explanation is that it dries out hair, leaving it brittle. This claim can be seen on multiple sources such as naturallycurly.com, but there does not appear to be published research on the topic. In the case of hydrogen peroxide, it is believed that it is highly damaging to hair according to many sources. However, the extent to which hair is impacted by these chemicals does not seem to be publicly known, and beginning to determine this is the primary focus of this study.

According to Franbourg et al., there are measurable differences between the physical properties of hair from different ethnicities.² The article found that while there are some similarities between hair from different ethnicities, there are very notable differences between the radial swelling, geometric characteristics, and the mechanical characteristics. Because of the observed measurable difference in physical properties based on ethnicity, hair samples for this study were taken all from one source, a 21-year-old Caucasian female, to limit the number of variables and allow all samples to be compared to one another. Furthermore, this study relies on "Human Hair: A Unique Physicochemical Composite" by L.J. Wolfram, which describes the chemical, physical, and mechanical characteristics of hair. While this source included a large amount of information, the most relevant piece is a table of the amino acid composition of human hair and how it differs between different ethnicities (Appendix A). This table will be used as a reference point in this study because understanding the typical amino acid composition of hair is highly beneficial when examining why certain chemicals impact hair the way they do, as different amino acids react differently with certain chemicals.

Another component to consider when evaluating chemical impact on hair is hair growth.³ Hair growth consists of three phases: anagen, catagen, and telogen. While this article does not discuss how the mechanical behaviors of hair may differ in different stages, it is possible that hair may behave differently at different stages. If according to this source, an average of 84% of hairs are in the anagen phase—which is when the hair is actively growing—and 16% are in either catagen or telogen, then it is possible that roughly 16% of the sample could be outliers due to being in a

2 *Current Research on Ethnic Hair* by A. Franbourg, P. Hallegot, F. Baltenneck, C. Toutain, and F. Leroy.

3 *Structure and Function of Skin, Hair and Nails* by J.E. Lai-Cheong, and J.A. McGrath.

different stage of growth. This piece of information may be useful when examining the results of the hair trials, because if the amount of outliers is close to 16% that may indicate that the mechanical properties of hair change during different phases of growth.

The hair alone does not account for the possible external conditions, like weather, that can predispose the hair to be impacted in a certain way by the chemical components. The structure and mechanical properties of hair vary under external environmental conditions. For this study, the tensile properties of hair under different strain rates, relative humidities, and temperatures were studied and examined. Multiple figures from this study are used as reference points in the procedure, including the 3D structure of hair, images showing the fracture surfaces at different strain rates, and a plot of how stress and strain vary with relative humidity (Appendices B, C, and D). These figures help to provide a clearer understanding of factors that impact the stress and strain of hair as well as a better understanding of the way that hair fractures. Because the hair sample is coming from a single source, the environmental impact on the hair can be controlled effectively.

Using this information, the goal of this study is to determine how citric acid, hydrogen peroxide, and sodium chloride impact hair by answering the following questions:

Is there a significant difference between the average stress and strain for hair samples in different treatment groups?

If there is a significant difference in the stress and strain, does there appear to be a clear indication why this difference occurs, based on existing knowledge of hair?

Based on differences that may be observed, should hair products containing any of these chemicals be avoided?

Methods

Sample Collection

All samples were donated from one source to limit variables that could impact results such as age or ethnic background. The student researcher volunteered to donate the hair samples, and IRB approval was obtained to use these hair samples for research purposes. Each sample was cut to 5-8 inches in length and was cut from the source by a professional hairdresser. The samples were allowed to dry thoroughly before any testing was done.

Sample Prep

Multiple treatment groups were done with the primary difference being the identity of the chemical used in the treatment solution. The identities of these chemicals are citric acid, hydrogen peroxide, and sodium chloride (salt). Two different control groups were also done, with one set not being soaked in any solution, and one using DI water in place of a chemical solution.

For each treatment group, a solution was made with the designated chemical. The desired number of hairs were inserted into a scintillation vial (10 hairs for the main treatment groups), and the solution was added. In the case that the hairs

floated to the top of the solution, they were pushed down into the solution with a pair of forceps. Additional solution was then added to reach the top of the vial. The filled vials were then capped and stored for multiple days. Once the desired amount of time passed (four days for the main treatment groups), the hair samples were carefully removed from the solution with a pair of forceps, placed on a piece of paper towel, rinsed thoroughly with DI water, patted dry with more paper towel, and placed in a clean beaker which was put in a desiccator for multiple days to allow the hairs to dry thoroughly.

Sample Examination

After each sample was subjected to a particular treatment, the sample examination began. The sample examination consisted primarily of measuring stress and strain of the hair. For this process, all the data and measurements were recorded in an Excel spreadsheet. An example of this is shown below in Figure 1.

Starting Length (mm)	63.9
Break Length (mm)	104.5
Delta Length (mm)	40.6
Break Force (N)	1.043
Measured Diameter	0.08519
Average Hair Radius(mm)	0.04260
Cross Sectional Area (mm^2)	0.005700
Area (mm^3)	0.3642
Stress (N/mm^2)	183.0
Strain	0.635

Figure 1: Example Data.

Before beginning the testing process, the hair diameter was measured using a ProScope portable digital microscope with the m200 lens. To do this, an image of the hair was taken using the portable microscope connected to a laptop, and the diameter of the hair was determined using ImageJ. Once the diameter was determined, the hair was then loaded into the testing apparatus which is shown in Appendix E and F. The hair was first clamped onto the force gauge, after the hair was clamped to the force gauge, the force was zeroed in Logger Pro, a data logging software compatible with the sensors used. The hair was then clamped to the apparatus and pulled taught, to the point just before a force reading began to register. Once the hair was clamped on both ends and pulled taught the start length was measured using a digital caliper, the length measured is the length of the hair from tip of clamp to tip of clamp.

Once the hair is fully loaded and the start length is measured, Open Broadcaster Software (OBS) is prepared to record the pull test. This recording includes a video of the caliper showing a change in length, a recording of the hair as it was being pulled, and a screen recording of the force reading in Logger Pro. Logger Pro was prepared by making sure it had been zeroed as described above, and that the duration was set to 1000s to prevent the data recording from cutting

off early. The duration is set to 1000s by going to experiment, data collection, and entering 1000 into the duration box.

Once OBS and Logger Pro were prepared, the pull test was ready to begin. To do this, the caliper was set up to record the change in distance as shown in Appendix C, collection was started in Logger Pro, and recording was initiated in OBS. Once all of this was ready the pull could begin. The apparatus was cranked slowly to pull the hair and was cranked until the hair broke. Once the hair broke, collection was ended in Logger Pro, and recording was ended in OBS. The video taken using OBS was then examined to collect the final change in length and the break force. Using this data and the data collected before the pull test, stress and strain were calculated.

$$Stress = \frac{Break\ Force\ (N)}{Cross\ Sectional\ Area\ (mm^2)}$$

$$Cross\ Sectional\ Area = \pi * Radius^2 = \pi * \left(\frac{Diameter}{2}\right)^2$$

$$Strain = \frac{\Delta Length}{Start\ Length}$$

These steps were repeated for each individual hair and all data was recorded into Excel spreadsheets.

Results

When comparing the results of the chemical trials to the two control groups, there appears to be varying significance. In comparison to the no soak control group, the DI water soak, Peroxide soak, and citric acid soak all appear to have a significant difference in both stress and strain. But when comparing to the DI water soak control group, it appears that only peroxide and sodium chloride have a significant difference, but they only have a significant difference in the strain, not the stress.

Hair	Stress (N/mm^2)	Strain
1	199.4853735	0.474
2	201.473739	0.478
3	178.2535363	0.471
4	158.1615222	1.150
5	184.3650861	0.348
6	183.4408085	0.525
7	180.6726914	0.753
8	219.1229537	0.550
9	212.8697364	0.474
10	216.6079127	0.550
11	181.2376914	0.386
12	196.0367993	0.520
13	185.8929735	0.529
14	175.9617051	0.532
Average	190.9701806	0.553
ST Dev	17.38301157	0.195
% dev	9.102474279	35.24

Table 1: No Soak Control Data.

Table 1 includes the stress and strain values for the no soak control. These samples were tested after the hair samples were collected and dried, and no soak was done.

Hair	Stress (N/mm ²)	Strain
1	182.99	1.5739
2	180.19	1.6933
3	196.49	2.0637
4	158.01	2.1137
5	156.18	1.7582
6	223.81	1.5719
7	157.82	2.1143
8	138.37	1.8479
9	170.86	1.8275
10	189.42	0.9896
Average	175.41	1.76
ST Dev	24.58	0.34
% Deviation	14.01	19.21

Table 2a: DI Water Control Set 1.

Hair	Stress (N/mm ²)	Strain
1	160.47	1.7604
2	189.75	1.9084
3	178.91	2.8870
4	161.24	2.0324
5	165.72	1.7820
6	185.25	1.6356
7	110.28	1.8671
8	148.71	1.7055
9	170.59	1.8648
10	138.35	2.0844
Average	160.93	1.95
ST Dev	23.77	0.36
% Deviation	14.77	18.24

Table 2b: DI Water Control Set 2.

Hair	Stress (N/mm ²)	Strain
Average	168.1705	1.85408
ST Dev	24.68114	0.352367
% Deviation	14.67626	19.00493

Table 2c: DI Water Data Combined.

Table 2 includes the stress and strain values for the DI water control. These samples were subjected to a DI water soak for a total four days. Two sets of ten hairs were subjected to this treatment and split into set 1 and set 2. Table 2 is split into three tables, Table 2a, 2b, and 2c. Table 2a includes the stress and strain values for set 1, Table 2b includes the stress and strain values for set 2, and Table 2c includes the average, standard deviation, and % deviation for set 1 and 2 combined.

Hair	Stress (N/mm^2)	Strain
1	150.99	0.7195
2	148.83	0.6534
3	135.11	0.6949
4	146.69	0.6698
5	125.34	0.5347
6	178.97	0.6995
7	149.03	0.9628
8	146.95	0.5679
9	134.80	0.5116
10	207.73	0.6116
Average	152.45	0.6600
ST Dev	24.03	0.1300
% Deviation	15.76	19.27

Table 3a: Peroxide Set 1.

Hair	Stress (N/mm^2)	Strain
1	146.96	1.5612
2	89.67	1.8136
3	171.48	1.6129
4	161.21	1.6788
5	162.10	1.5590
6	151.41	1.5611
7	188.59	1.5492
8	143.10	1.3037
9	167.39	1.5020
10	161.11	1.6030
Average	154.30	1.57
ST Dev	26.16	0.13
% Deviation	16.96	8.20

Table 3b: Peroxide Set 2.

Hair	Stress (N/mm^2)	Strain
Average	153.373	1.11851
ST Dev	24.46903	0.484193
% Deviation	15.95393	43.2891

Table 3c: Peroxide Data Combined.

Table 3 includes the stress and strain values for the peroxide chemical treatment. Two sets of ten hairs were subjected to this treatment and split into set 1 and set 2. These samples were run with a 3% hydrogen peroxide solution for a total of four days. Table 3 is split into three tables, Table 3a, 3b, and 3c. Table 3a includes the stress and strain values for set 1, Table 3b includes the stress and strain values for set 2, and Table 3c includes the average, standard deviation, and % deviation for set 1 and 2 combined.

Hair	Stress (N/mm^2)	Strain
1	180.04	1.3901
2	142.86	1.7917
3	119.49	1.7591
4	127.24	1.7034
5	152.12	1.8217
6	148.85	1.7042
7	122.23	1.8490
8	131.85	1.6943
9	151.65	1.7324
10	134.61	1.5597
Average	141.09	1.70
ST Dev	18.12	0.14
% Deviation	12.84	7.98

Table 4a: Citric Acid Set 1.

Hair	Stress (N/mm^2)	Strain
1	179.65	2.0619
2	175.26	1.7732
3	143.74	1.8388
4	191.29	2.0741
5	173.71	2.0397
6	148.20	1.9218
7	129.13	2.3945
8	198.94	1.9210
9	165.21	1.8885
10	171.18	1.8842
Average	167.63	1.98
ST Dev	21.68	0.18
% Deviation	12.93	8.88

Table 4b: Citric Acid Set 2.

Hair	Stress (N/mm^2)	Strain
Average	154.3625	1.840165
ST Dev	23.73636	0.20946
% Deviation	15.37702	11.38265

Table 4c: Citric Acid Set 3.

Table 4 includes the stress and strain values for the citric acid chemical treatment. Two sets of ten hairs were subjected to this treatment and split into set 1 and set 2. These samples were run with a 50.128% w/w citric acid solution for a total of four days. Table 4 is split into three tables, Table 4a, 4b, and 4c. Table 4a includes the stress and strain values for set 1, Table 4b includes the stress and strain values for set 2, and Table 4c includes the average, standard deviation, and % deviation for set 1 and 2 combined.

Hair	Stress (N/mm^2)	Strain
1	195.6	0.439
2	235.8	0.469
3	198.9	0.543
4	171.7	0.511
Average	200.5	0.490
ST Dev	26.5	0.053
% Dev	13.2	10.85

Table 5: Sodium Chloride Pre-Trial.

Table 5 includes the stress and strain values for the sodium chloride treatment. These samples were run with a 25.098% sodium chloride solution for a total of four days. The sodium chloride treatment data is more limited than the other treatments as only a pre-trial including four samples was run.

Discussion

Table 6 compares the stress and strain values of each treatment to the no-soak control group. Table 7 compares the stress and strain values of each treatment to the DI water control group. These comparisons were done by running a two-sample t-test assuming unequal variances for each treatment group using the data from Tables 1-5; the Excel spreadsheet showing these calculations is in Appendix H. In both tables, the p-values that show significance are highlighted in green, and the p-values that don't show significance are highlighted in red. At a 95% significance level, alpha (α) is 0.05, so a p-value less than 0.05 shows significance, and a p-value higher than 0.05 shows that there is no significance. Significance in this value means that there is a significant difference between the control value and the treatment value.

From Table 6 it can be determined that the DI water soak, hydrogen peroxide soak, and citric acid soak all appear to have a significant difference in both stress and strain from the no soak control. This means that all these treatments had some measurable impact on the hair. When examining the significance, it appears that all three of these treatments had a negative significance in the stress and positive significance in the strain. This means that the force required to break the hair decreased. It also means that the amount that the hair stretched before breaking increased. While the sodium chloride values do not appear to show significance in this table, it is possible that the lack of significant results is due to a small sample size and more data should be collected to determine if there are any significant impacts on hair from sodium chloride.

From Table 7 it can be determined that only the stress values for peroxide and sodium chloride have significance in comparison to the DI water control. Both peroxide and sodium chloride show a negative significance in the strain value, which means that the strain values for both peroxide and sodium chloride were significantly lower than strain values for the DI water control samples. Because $\text{Strain} = (\text{Change in Length}) / (\text{Original Length})$, this means that peroxide and sodium chloride seem to make the hair less stretchy in comparison to DI water, but more stretchy in comparison to the no soak control. This could be for many reasons, such as potentially breaking bonds in the hair, allowing it to stretch more easily. However, to determine why the hair becomes more stretchy, further research needs to be done. When compared to the DI water control, citric acid does not appear to have any significance.

When comparing the two tables, there appears to be a substantial difference in what treatments have a significant impact on hair. This may be due to the significant impact that DI water appears to have on hair in comparison to the no soak control. Because of this significant difference seen from DI water, it is difficult to determine how many of the changes seen from the treatments are due to the DI water in the solution. Further research is needed.

Figures 2 and 3 provide a visual comparison of the stress and strain values for every treatment to better understand why there is a difference between whether a treatment has a positive or negative significance between the no soak and DI water soak statistical comparison.

Group	Stress		Strain	
	t-value	p-value	t-value	p-value
No Soak Control	Control (Table 1)			
DI Water Control	2.036933343	-0.00343333	2.03951345	+9.3073E-15
Peroxide	2.036933343	-9.9425E-06	2.05183052	+6.6802E-05
Citric Acid	2.036933343	-1.1438E-05	2.04522964	+1.6116E-17
Sodium Chloride Pre-Trial	2.776445105	+0.53417312	2.1199053	-0.28943219

Table 6: All Stress and Strain Data Compared to No Soak Control.

Group	Stress		Strain	
	t-value	p-value	t-value	p-value
DI Water Control	Control			
Peroxide	2.024394164	-0.064489673	2.030107928	-3.59703E-06
Citric Acid	2.024394164	-0.079269531	2.039513446	-0.880321243
Sodium Chloride Pre-Trial	2.776445105	+0.08720836	2.079613845	-1.46802E-13

Table 7: All Stress and Strain Data Compared to DI Water Soak Control.

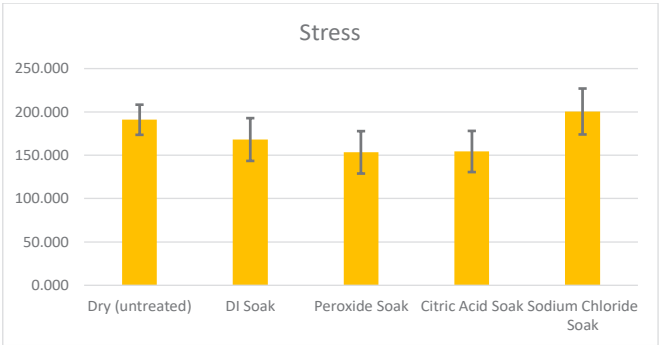


Figure 2: Average Stress with Standard Deviation.

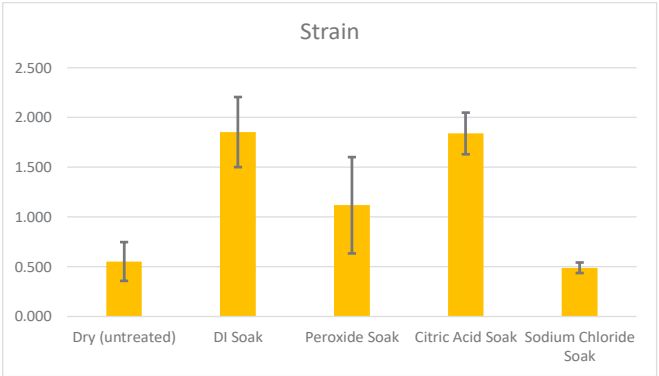


Figure 3: Average Strain with Standard Deviation.

Conclusion

The primary goal of this study was to determine if there is a significant impact on hair due to the chemical treatments (citric acid, peroxide, and sodium chloride). Based on the results of this study, it appears that there is a significant impact on hair by DI water, which impacts how clear the other results are. While it does appear that there may be some significance to how each of these chemicals interacts with hair, further research needs to be done to get a clearer understanding of how the other chemical treatments impact hair and how significant the impacts are.

There are a few limitations to this study. The primary limitation to note is that DI water appears to have a significant impact on hair. Because DI water is the solvent for the other chemical treatment solutions, this may impact the results of the study. Another limitation is small sample sizes. While the main treatments do have a fair number of samples (20 per treatment) the sodium chloride treatment has only had a pretreatment of four samples completed.

There are multiple potential future directions. The first would be to complete a full trial of the sodium chloride treatment because only a pretreatment was completed for this study. Another potential future direction would be to test other solvents that may have less of an impact on hair than DI water does so that a clearer analysis of the other chemical treatments can be completed. It may also be worthwhile to further study the impact that DI water has on hair to determine why it has the impact that it does. This study provides an introductory glance into the ways hair can be affected by various chemicals, but it also shows the need for further research into the topic.

Bibliography

Luqman, M. W.; Ali, R.; Khan, Z.; Ramzan, M. H.; Hanan, F.; Javaid, U. Effect of Topical Application of Hard Water in Weakening of Hair in Men. *J. Pak. Med. Assoc.* 2016, 66 (9), 1132–1136.

Franbourg, A.; Hallegot, P.; Baltenneck, F.; Toutain, C.; Leroy, F. Current Research on Ethnic Hair. *J. Am. Acad. Dermatol.* 2003, 48 (6 Suppl), S115-9. <https://doi.org/10.1067/mjd.2003.277>.

Wickett, R. R.; Kossmann, E.; Barel, A.; Demeester, N.; Clarys, P.; Vanden Berghe, D.; Calomme, M. Effect of Oral Intake of Choline-Stabilized Orthosilicic Acid on Hair Tensile Strength and Morphology in Women with Fine Hair. *Arch. Derm. Res.* 2007, 299 (10), 499–505. <https://doi.org/10.1007/s00403-007-0796-z>.

Wolfram, L. J. Human Hair: A Unique Physicochemical Composite. *J. Am. Acad. Dermatol.* 2003, 48 (6), S106–S114. <https://doi.org/10.1067/mjd.2003.276>.

Nail and hair testing <https://www.amalabs.com/services/testing/hair-nail/> (accessed 2022 -04 -26).

Sajno, T. Porosity & Elasticity Test.

McMullen, R. L.; Zhang, G.; Gillece, T. Quantifying Hair Shape and Hair Damage Induced during Reshaping of Hair. *J. Cosmet. Sci.* 2015, 66 (6), 379–409.

Lai-Cheong, J. E.; McGrath, J. A. Structure and Function of Skin, Hair and Nails. *Medicine (Abingdon)* 2013, 41 (6), 317–320. <https://doi.org/10.1016/j.mpmed.2013.04.017>.

Yu, Y.; Yang, W.; Wang, B.; Meyers, M. A. Structure and Mechanical Behavior of Human Hair. *Mater. Sci. Eng. C Mater. Biol. Appl.* 2017, 73, 152–163. <https://doi.org/10.1016/j.msec.2016.12.008>.

Istrate, D.; Popescu, C.; Rafik, M. E.; Möller, M. The Effect of PH on the Thermal Stability of Fibrous Hard Alpha-Keratins. *Polym. Degrad. Stab.* 2013, 98 (2), 542–549. <https://doi.org/10.1016/j.polymdegradstab.2012.12.001>.

Appendices

Table I. Amino acid composition of human hair of various ethnic origins (μM/g)

Amino acid	Hair type		
	African	Brown/Caucasian	Asian
Alanine	370-509	345-475	370-415
Arginine	482-540	466-534	492-510
Aspartic acid	436-452	407-455	456-500
Cysteic acid	10-30	22-58	35-41
1/2 Cystine	1310-1420	1268-1608	1175-1357
Glutamic acid	915-1017	868-1053	1026-1082
Glycine	467-542	450-544	454-498
Histidine	60-85	56-70	57-63
Isoleucine	224-282	188-255	205-244
Leucine	484-573	442-558	515-546
Lysine	198-236	178-220	182-196
Methionine	6-42	8-54	21-37
Phenylalanine	139-181	124-150	129-143
Proline	642-697	588-753	615-683
Serine	672-1130	851-1076	986-1101
Threonine	580-618	542-654	568-593
Tyrosine	179-202	126-194	131-170
Valine	442-573	405-542	421-493

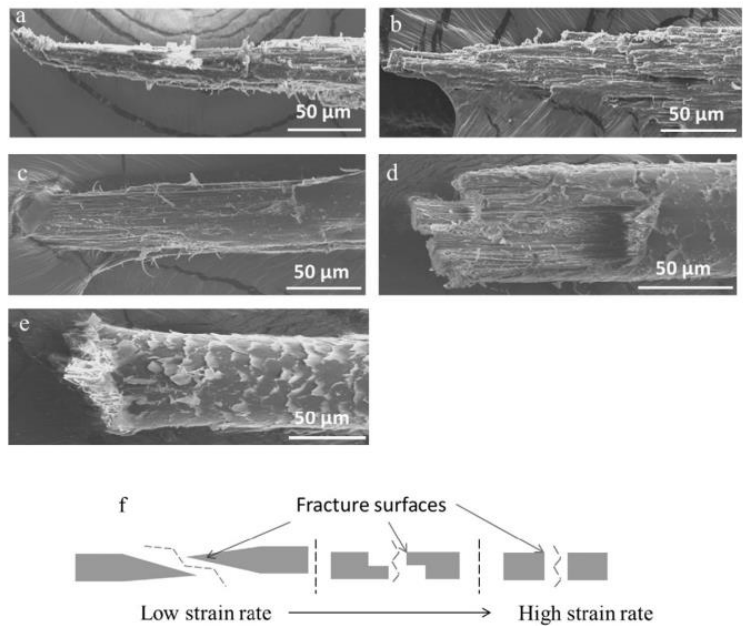


Fig. 10. Fracture surface of hair specimen tested at (a) 10^{-4} , (b) 10^{-3} , (c) 10^{-2} , (d) 10^{-1} , and (e) 10^0 s^{-1} strain rates and (f) schematic representations of fracture modes from low strain rate to high strain rate (at low strain rates, fiber pulling and inter-fiber sliding is more prominent. At high strain rates, fracture surface is flat).

Appendix B: Structure and Mechanical Behavior of Human Hair
by Y. Yu, W. Yang, B. Wang, and M.A Meyers.

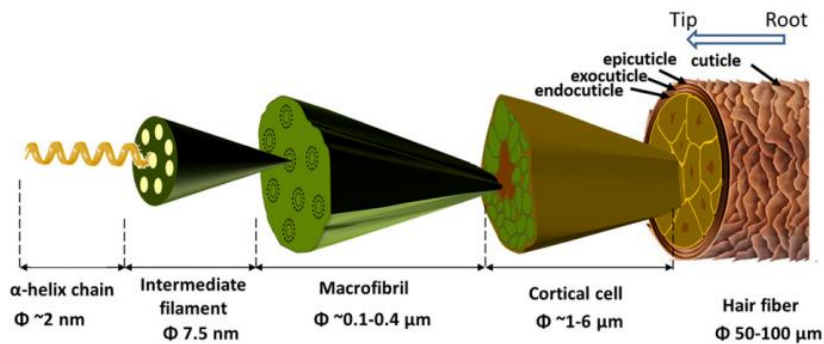


Fig. 1. Schematic representation of hierarchical structure in human hair starting at α -helix chains and progressing to the entire section.

Appendix C: Structure and Mechanical Behavior of Human Hair
by Y. Yu, W. Yang, B. Wang, and M.A Meyers.

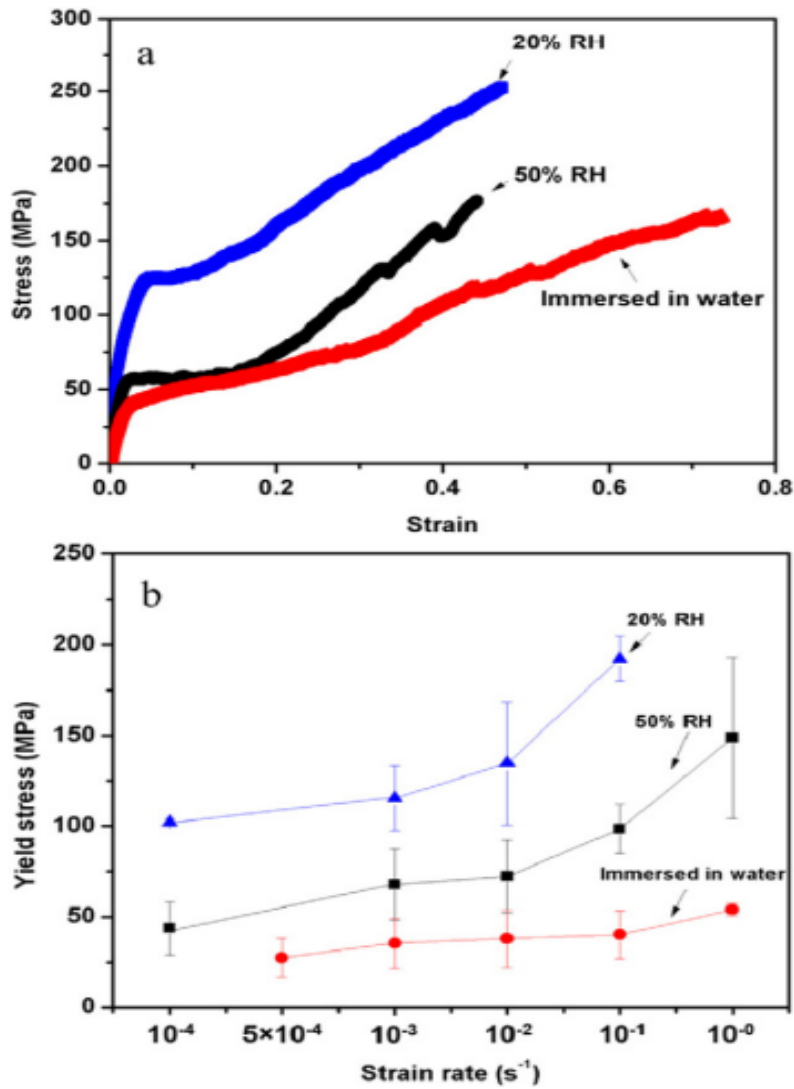
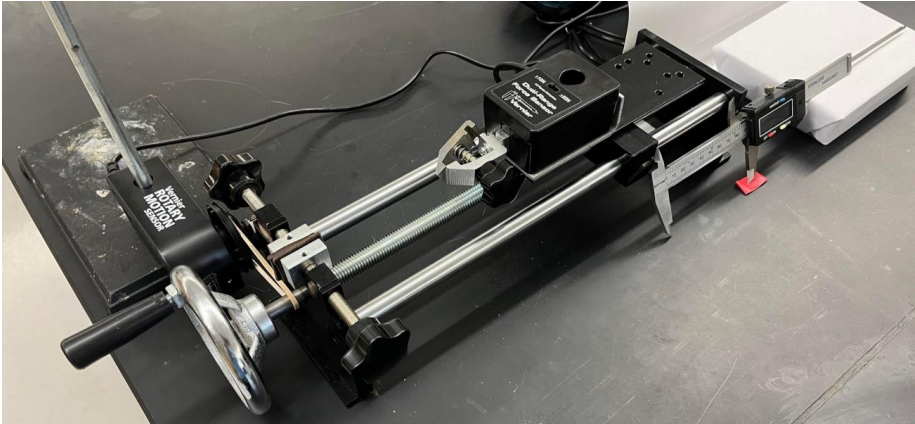
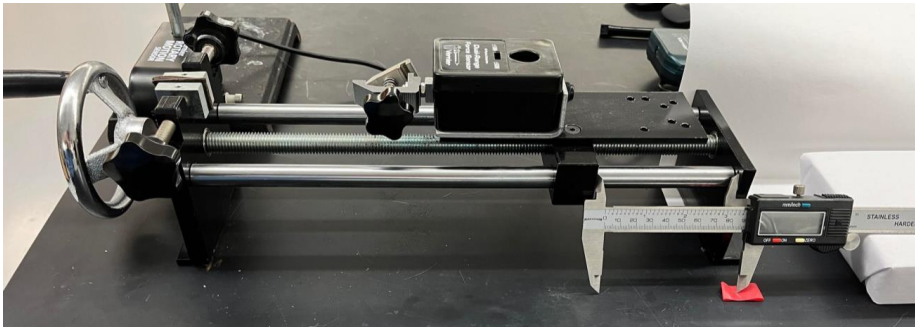


Fig. 5. (a) Typical stress-strain curves at different relative humidities and (b) yield stress as a function of strain rate (error bars represent standard deviation).

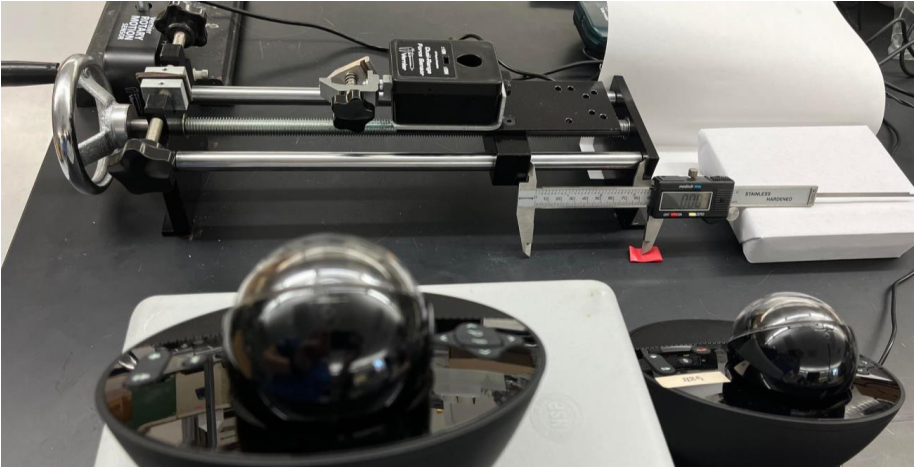
Appendix D: Structure and Mechanical Behavior of Human Hair
by Y. Yu, W. Yang, B. Wang, and M.A Meyers.



Appendix E.



Appendix F.



Appendix G.

No Soak Control Data		
Hair	Stress (N/mm ²)	Strain
1	199.4853735	0.474
2	201.473739	0.478
3	178.2535363	0.471
4	158.1615222	1.15
5	184.3650861	0.348
6	183.4408085	0.525
7	180.6726914	0.753
8	219.1229537	0.55
9	212.8697364	0.474
10	216.6079127	0.55
11	181.2376914	0.386
12	196.0367993	0.52
13	185.8929735	0.529
14	175.9617051	0.532
Average	190.9701806	0.553
ST Dev	17.38301157	0.195
% dev	9.102474279	35.24

Group	Stress		Strain	
	t-value	p-value	t-value	p-value
No Soak Control		Control		
DI Water Control	2.036933343	0.003433329	2.039513446	9.30726E-15
Peroxide	2.036933343	9.94246E-06	2.051830516	6.68025E-05
Citric Acid	2.036933343	1.14381E-05	2.045229642	1.61156E-17
Sodium Chloride Pre-Trial	2.776445105	0.534173123	2.119905299	0.289432187

DI Water Control Set 1		
Hair	Stress (N/mm ²)	Strain
1	182.99	1.5739
2	180.19	1.6933
3	196.49	2.0637
4	158.01	2.1137
5	156.18	1.7582
6	223.81	1.5719
7	157.82	2.1143
8	138.37	1.8479
9	170.86	1.8275
10	189.42	0.9896
Average	175.41	1.76
ST Dev	24.58	0.34
% Deviation	14.01	19.21

DI Water Control Set 2		
Hair	Stress (N/mm ²)	Strain
1	160.47	1.7604
2	189.75	1.9084
3	178.91	2.887
4	161.24	2.0324
5	165.72	1.782
6	185.25	1.6356
7	110.28	1.8671
8	148.71	1.7055
9	170.59	1.8648
10	138.35	2.0844
Average	160.93	1.95
ST Dev	23.77	0.36
% Deviation	14.77	18.24

DI Water Control Data Combined		
Hair	Stress (N/mm ²)	Strain
1	182.99	1.5739
2	180.19	1.6933
3	196.49	2.0637
4	158.01	2.1137
5	156.18	1.7582
6	223.81	1.5719
7	157.82	2.1143
8	138.37	1.8479
9	170.86	1.8275
10	189.42	0.9896
1	160.47	1.7604
2	189.75	1.9084
3	178.91	2.887
4	161.24	2.0324
5	165.72	1.782
6	185.25	1.6356
7	110.28	1.8671
8	148.71	1.7055
9	170.59	1.8648
10	138.35	2.0844
Average	168.1705	1.85408
ST Dev	24.68113694	0.352366631
% Deviation	14.67625829	19.00493135

Appendix H: No Soak Control Comparison.

Peroxide Set 1		
Hair	Stress (N/mm^2)	Strain
1	150.99	0.72
2	148.83	0.653
3	135.11	0.695
4	146.69	0.67
5	125.34	0.535
6	178.97	0.7
7	149.03	0.963
8	146.95	0.568
9	134.8	0.512
10	207.73	0.612
Average	152.45	0.66
ST Dev	24.03	0.13
% Deviation	15.76	19.27

Peroxide Set 2		
Hair	Stress (N/mm^2)	Strain
1	146.96	1.561
2	89.67	1.814
3	171.48	1.613
4	161.21	1.679
5	162.1	1.559
6	151.41	1.561
7	188.59	1.549
8	143.1	1.304
9	167.39	1.502
10	161.11	1.603
Average	154.3	1.57
ST Dev	26.16	0.13
% Deviation	16.96	8.2

Peroxide Data Combined		
Hair	Stress (N/mm^2)	Strain
1	150.99	0.7195
2	148.83	0.6534
3	135.11	0.6949
4	146.69	0.6698
5	125.34	0.5347
6	178.97	0.6995
7	149.03	0.9628
8	146.95	0.5679
9	134.8	0.5116
10	207.73	0.6116
1	146.96	1.5612
2	89.67	1.8136
3	171.48	1.6129
4	161.21	1.6788
5	162.1	1.559
6	151.41	1.5611
7	188.59	1.5492
8	143.1	1.3037
9	167.39	1.502
10	161.11	1.603
Average	153.373	1.11851
ST Dev	24.46902749	0.484192924
% Deviation	15.95393419	43.289101

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	190.9701807	168.1705
Variance	302.169091	609.1585208
Observations	14	20
Hypothesized		
Mean Difference	0	
df	32	
t Stat	3.160487977	
P(T<=t) one-tail	0.001716664	
t Critical one-tail		
	1.693888748	
P(T<=t) two-tail	0.003433329	
t Critical two-tail		
	2.036933343	

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	0.552857143	1.85408
Variance	0.038004747	0.124162243
Observations	14	20
Hypothesized		
Mean Difference	0	
df	31	
t Stat	-13.77534989	
P(T<=t) one-tail	4.65363E-15	
t Critical one-tail		
	1.695518783	
P(T<=t) two-tail	9.30726E-15	
t Critical two-tail		
	2.039513446	

Citric Acid Set 1		
Hair	Stress (N/mm^2)	Strain
1	180.04	1.39
2	142.86	1.792
3	119.49	1.759
4	127.24	1.703
5	152.12	1.822
6	148.85	1.704
7	122.23	1.849
8	131.85	1.694
9	151.65	1.732
10	134.61	1.56
Average	141.09	1.7
ST Dev	18.12	0.14
% Deviation	12.84	7.98

Citric Acid Set 2		
Hair	Stress (N/mm^2)	Strain
1	179.65	2.062
2	175.26	1.773
3	143.74	1.839
4	191.29	2.074
5	173.71	2.04
6	148.2	1.922
7	129.13	2.395
8	198.94	1.921
9	165.21	1.889
10	171.18	1.884
Average	167.63	1.98
ST Dev	21.68	0.18
% Deviation	12.93	8.88

Citric Acid Data Combined		
Hair	Stress (N/mm^2)	Strain
1	180.04	1.3901
2	142.86	1.7917
3	119.49	1.7591
4	127.24	1.7034
5	152.12	1.8217
6	148.85	1.7042
7	122.23	1.849
8	131.85	1.6943
9	151.65	1.7324
10	134.61	1.5597
1	179.65	2.0619
2	175.26	1.7732
3	143.74	1.8388
4	191.29	2.0741
5	173.71	2.0397
6	148.2	1.9218
7	129.13	2.3945
8	198.94	1.921
9	165.21	1.8885
10	171.18	1.8842
Average	154.3625	1.840165
ST Dev	23.7363596	0.209459601
% Deviation	15.3770246	11.38265325

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	190.9701807	153.373
Variance	302.169091	598.7333063
Observations	14	20
Hypothesized Me	0	
df	32	
t Stat	5.238013673	
P(T<=t) one-tail	4.97123E-06	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	9.94246E-06	
t Critical two-tail	2.036933343	

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	0.552857143	1.11851
Variance	0.038004747	0.234442787
Observations	14	20
Hypothesized		
Mean Difference	0	
df	27	
t Stat	-4.707768016	
P(T<=t) one-tail	3.34012E-05	
t Critical one-tail	1.703288446	
P(T<=t) two-tail	6.68025E-05	
t Critical two-tail	2.051830516	

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	190.9701807	154.3625
Variance	302.169091	563.4147671
Observations	14	20
Hypothesized Me	0	
df	32	
t Stat	5.189877949	
P(T<=t) one-tail	5.71904E-06	
t Critical one-tail	1.693888748	
P(T<=t) two-tail	1.14381E-05	
t Critical two-tail	2.036933343	

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	190.9701807	200.5
Variance	302.169091	700.7
Observations	14	4
Hypothesized	0	
Mean Difference	0	
df	4	
t Stat	-0.679388059	
P(T<=t) one-tail	0.267086561	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.534173123	
t Critical two-tail	2.776445105	

Sodium Chloride Pre-Trial		
Hair	Stress (N/mm^2)	Strain
1	195.6	0.439
2	235.8	0.469
3	198.9	0.543
4	171.7	0.511
Average	200.5	0.49
ST Dev	26.5	0.053
% Dev	13.2	10.85

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	0.552857143	1.840165
Variance	0.038004747	0.043873324
Observations	14	20
Hypothesized	0	
Mean Difference	0	
df	29	
t Stat	-18.3745735	
P(T<=t) one-tail	8.05782E-18	
t Critical one-tail	1.699127027	
P(T<=t) two-tail	1.61156E-17	
t Critical two-tail	2.045229642	

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	0.552857143	0.4905
Variance	0.038004747	0.002097
Observations	14	4
Hypothesized Me	0	
df	16	
t Stat	1.095693607	
P(T<=t) one-tail	0.144716093	
t Critical one-tail	1.745883676	
P(T<=t) two-tail	0.289432187	
t Critical two-tail	2.119905299	

Peroxide Set 1		
Hair	Stress (N/mm ²)	Strain
1	150.99	0.7195
2	148.83	0.6534
3	135.11	0.6949
4	146.69	0.6698
5	125.34	0.5347
6	178.97	0.6995
7	149.03	0.9628
8	146.95	0.5679
9	134.8	0.5116
10	207.73	0.6116
Average	152.45	0.66
ST Dev	24.03	0.13
% Deviation	15.76	19.27

Peroxide Set 2		
Hair	Stress (N/mm ²)	Strain
1	146.96	1.5612
2	89.67	1.8136
3	171.48	1.6129
4	161.21	1.6788
5	162.1	1.559
6	151.41	1.5611
7	188.59	1.5492
8	143.1	1.3037
9	167.39	1.502
10	161.11	1.603
Average	154.3	1.57
ST Dev	26.16	0.13
% Deviation	16.96	8.2

Group	Stress		Strain	
	t-value	p-value	t-value	p-value
DI Water Control	Control			
Peroxide	2.024394164	0.064489673	2.030107928	3.59703E-06
Citric Acid	2.024394164	0.079269531	2.039513446	0.880321243
Sodium Chloride Pre-Trial	2.776445105	0.08720836	2.079613845	1.46802E-13

DI Water Control Set 1		
Hair	Stress (N/mm ²)	Strain
1	182.99	1.5739
2	180.19	1.6933
3	196.49	2.0637
4	158.01	2.1137
5	156.18	1.7582
6	223.81	1.5719
7	157.82	2.1143
8	138.37	1.8479
9	170.86	1.8275
10	189.42	0.9896
Average	175.41	1.76
ST Dev	24.58	0.34
% Deviation	14.01	19.21

DI Water Control Set 2		
Hair	Stress (N/mm ²)	Strain
1	160.47	1.7604
2	189.75	1.9084
3	178.91	2.887
4	161.24	2.0324
5	165.72	1.782
6	185.25	1.6356
7	110.28	1.8671
8	148.71	1.7055
9	170.59	1.8648
10	138.35	2.0844
Average	160.93	1.95
ST Dev	23.77	0.36
% Deviation	14.77	18.24

DI Water Control Data Combined		
Hair	Stress (N/mm ²)	Strain
1	182.99	1.5739
2	180.19	1.6933
3	196.49	2.0637
4	158.01	2.1137
5	156.18	1.7582
6	223.81	1.5719
7	157.82	2.1143
8	138.37	1.8479
9	170.86	1.8275
10	189.42	0.9896
1	160.47	1.7604
2	189.75	1.9084
3	178.91	2.887
4	161.24	2.0324
5	165.72	1.782
6	185.25	1.6356
7	110.28	1.8671
8	148.71	1.7055
9	170.59	1.8648
10	138.35	2.0844
Average	168.1705	1.85408
ST Dev	24.68113694	0.352366631
% Deviation	14.67625829	19.00493135

Appendix H: DI Water Soak Comparison.

Citric Acid Set 1		
Hair	Stress (N/mm ²)	Strain
1	180.04	1.3901
2	142.86	1.7917
3	119.49	1.7591
4	127.24	1.7034
5	152.12	1.8217
6	148.85	1.7042
7	122.23	1.849
8	131.85	1.6943
9	151.65	1.7324
10	134.61	1.5597
Average	141.09	1.7
ST Dev	18.12	0.14
% Deviation	12.84	7.98

Citric Acid Set 2		
Hair	Stress (N/mm ²)	Strain
1	179.65	2.0619
2	175.26	1.7732
3	143.74	1.8388
4	191.29	2.0741
5	173.71	2.0397
6	148.2	1.9218
7	129.13	2.3945
8	198.94	1.921
9	165.21	1.8885
10	171.18	1.8842
Average	167.63	1.98
ST Dev	21.68	0.18
% Deviation	12.93	8.88

Peroxide Data Combined		
Hair	Stress (N/mm ²)	Strain
1	150.99	0.7195
2	148.83	0.6534
3	135.11	0.6949
4	146.69	0.6698
5	125.34	0.5347
6	178.97	0.6995
7	149.03	0.9628
8	146.95	0.5679
9	134.8	0.5116
10	207.73	0.6116
1	146.96	1.5612
2	89.67	1.8136
3	171.48	1.6129
4	161.21	1.6788
5	162.1	1.559
6	151.41	1.5611
7	188.59	1.5492
8	143.1	1.3037
9	167.39	1.502
10	161.11	1.603
Average	153.373	1.11851
ST Dev	24.46902749	0.484192924
% Deviation	15.95393419	43.289101

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	168.1705	153.373
Variance	609.1585208	598.7333063
Observations	20	20
Hypothesized Mean Difference	0	
df	38	
t Stat	1.904098124	
P(T<=t) one-tail	0.032244836	
t Critical one-tail	1.68595446	
P(T<=t) two-tail	0.064489673	
t Critical two-tail	2.024394164	

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	1.85408	1.11851
Variance	0.124162243	0.234442787
Observations	20	20
Hypothesized Mean Difference	0	
df	35	
t Stat	5.493268383	
P(T<=t) one-tail	1.79852E-06	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	3.59703E-06	
t Critical two-tail	2.030107928	

Sodium Chloride Pre-Trial		
Hair	Stress (N/mm ²)	Strain
1	195.6	0.439
2	235.8	0.469
3	198.9	0.543
4	171.7	0.511
Average	200.5	0.49
ST Dev	26.5	0.053
% Dev	13.2	10.85

Citric Acid Set 1		
Hair	Stress (N/mm ²)	Strain
1	180.04	1.3901
2	142.86	1.7917
3	119.49	1.7591
4	127.24	1.7034
5	152.12	1.8217
6	148.85	1.7042
7	122.23	1.849
8	131.85	1.6943
9	151.65	1.7324
10	134.61	1.5597
Average	141.09	1.7
ST Dev	18.12	0.14
% Deviation	12.84	7.98

Citric Acid Set 2		
Hair	Stress (N/mm ²)	Strain
1	179.65	2.0619
2	175.26	1.7732
3	143.74	1.8388
4	191.29	2.0741
5	173.71	2.0397
6	148.2	1.9218
7	129.13	2.3945
8	198.94	1.921
9	165.21	1.8885
10	171.18	1.8842
Average	167.63	1.98
ST Dev	21.68	0.18
% Deviation	12.93	8.88

Peroxide Data Combined		
Hair	Stress (N/mm ²)	Strain
1	150.99	0.7195
2	148.83	0.6534
3	135.11	0.6949
4	146.69	0.6698
5	125.34	0.5347
6	178.97	0.6995
7	149.03	0.9628
8	146.95	0.5679
9	134.8	0.5116
10	207.73	0.6116
1	146.96	1.5612
2	89.67	1.8136
3	171.48	1.6129
4	161.21	1.6788
5	162.1	1.559
6	151.41	1.5611
7	188.59	1.5492
8	143.1	1.3037
9	167.39	1.502
10	161.11	1.603
Average	153.373	1.11851
ST Dev	24.46902749	0.484192924
% Deviation	15.95393419	43.289101

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	168.1705	153.373
Variance	609.1585208	598.7333063
Observations	20	20
Hypothesized Mean Difference	0	
df	38	
t Stat	1.904098124	
P(T<=t) one-tail	0.032244836	
t Critical one-tail	1.68595446	
P(T<=t) two-tail	0.064489673	
t Critical two-tail	2.024394164	

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	1.85408	1.11851
Variance	0.124162243	0.234442787
Observations	20	20
Hypothesized Mean Difference	0	
df	35	
t Stat	5.493268383	
P(T<=t) one-tail	1.79852E-06	
t Critical one-tail	1.689572458	
P(T<=t) two-tail	3.59703E-06	
t Critical two-tail	2.030107928	

Sodium Chloride Pre-Trial		
Hair	Stress (N/mm ²)	Strain
1	195.6	0.439
2	235.8	0.469
3	198.9	0.543
4	171.7	0.511
Average	200.5	0.49
ST Dev	26.5	0.053
% Dev	13.2	10.85

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	168.1705	154.3625
Variance	609.1585208	563.4147671
Observations	20	20
Hypothesized Mean Difference	0	
df	38	
t Stat	1.803332368	
P(T<=t) one-tail	0.039634766	
t Critical one-tail	1.68595446	
P(T<=t) two-tail	0.079269531	
t Critical two-tail	2.024394164	

t-Test: Two-Sample Assuming Unequal Variances for Stress		
	Variable 1	Variable 2
Mean	168.1705	200.5
Variance	609.1585208	700.7
Observations	20	4
Hypothesized Mean Difference	0	
df	4	
t Stat	-2.254512566	
P(T<=t) one-tail	0.04360418	
t Critical one-tail	2.131846786	
P(T<=t) two-tail	0.08720836	
t Critical two-tail	2.776445105	

Citric Acid Data Combined		
Hair	Stress (N/mm ²)	Strain
1	180.04	1.3901
2	142.86	1.7917
3	119.49	1.7591
4	127.24	1.7034
5	152.12	1.8217
6	148.85	1.7042
7	122.23	1.849
8	131.85	1.6943
9	151.65	1.7324
10	134.61	1.5597
1	179.65	2.0619
2	175.26	1.7732
3	143.74	1.8388
4	191.29	2.0741
5	173.71	2.0397
6	148.2	1.9218
7	129.13	2.3945
8	198.94	1.921
9	165.21	1.8885
10	171.18	1.8842
Average	154.3625	1.840165
ST Dev	23.7363596	0.209459601
% Deviation	15.3770246	11.38265325

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	1.85408	0.4905
Variance	0.124162243	0.002097
Observations	20	4
Hypothesized Mean Difference	0	
df	21	
t Stat	16.61869389	
P(T<=t) one-tail	7.34011E-14	
t Critical one-tail	1.720742903	
P(T<=t) two-tail	1.46802E-13	
t Critical two-tail	2.079613845	

t-Test: Two-Sample Assuming Unequal Variances for Strain		
	Variable 1	Variable 2
Mean	1.85408	1.840165
Variance	0.124162243	0.043873324
Observations	20	20
Hypothesized Mean Difference	0	
df	31	
t Stat	0.151809028	
P(T<=t) one-tail	0.440160621	
t Critical one-tail	1.695518783	
P(T<=t) two-tail	0.880321243	
t Critical two-tail	2.039513446	

Rare Vascular and Bryophyte Plant Survey: Diversity within the Devil's Punchbowl

Britney Serafina

Senior, B.S. Environmental Science

Faculty Advisor: Dr. Amanda Little

Abstract

Rare plant surveys are important for plant species conservation. These types of surveys help with research, monitoring, management, and citizen engagement. Rare species are important due to their impact on the environment, ecosystem functions, and ecosystem services. Since the Devil's Punchbowl is the most visited nature preserve in Dunn County, it is important to keep a record of the species present in order to document potential species loss. The site was surveyed weekly during the summer of 2022 to identify and document vascular and bryophyte plant species. Of the 206 vascular plant species found at the Devil's Punchbowl, about 78.9% are native, 6.7% are considered invasive, and 14.4% are classified as a subcategory of native or invasive. The mean coefficient of conservatism (C of C) of all the vascular species was 3.80. We found a total of nine different bryophyte communities within the Devil's Punchbowl with no rare mosses. The Devil's Punchbowl is a unique small preserve with a high species density and has many different natural communities within. Despite the lack of rare species, the Devil's Punchbowl still provides valuable contributions to plant conservation in the area.

Keywords: *Devil's Punchbowl, rare plants, bryophytes, plant survey, ferns, diversity*

Introduction

Many assume that since rare species consist of small populations, they have no effect on their environment or impact ecosystem functions. However, rare plant species provide a myriad of ecosystem services. Rare species overall can act as indicators of community diversity as they have been associated with different important roles within an ecosystem (Wiegand, 2020). The reasons why rare plant species matter differs due to their capabilities. Some species may directly provide a benefit such as food production, appreciation, or cultural services (Dee, 2019). Additionally, when rare plants provide cultural services, their role becomes more important in a human's perspective to conserve and protect. They may provide identity, a sense of place, or an iconic symbol in one's culture (Dee, 2019).

Rare species may also have functioning services that their ecosystems rely on, such as carbon storage, nitrogen fixation, and nutrient cycling (Dee, 2019; Wiegand, 2020). If they are the only species within a community that provides these functions, then without them, the health of the neighboring attributes, like soil and biota, may decline. Some rare species have the possibility to modify their local conditions that can benefit provides through species interactions. Mutualisms like plant-soil interactions can be beneficial, but also detrimental to the ecosystem if the mutualistic

partner populations decline (Dee, 2019). Rare species also play important roles in food webs and invasion resistance, acting as biological indicators of habitat health (Wiegand, 2020).

There are many different definitions of rarity, making it difficult to assign the title to a species. When there are a variety of meanings, it can make conservation decisions difficult (Dee, 2019). Overall, the definition of species rarity usually includes low abundance, habitat specificity, and/or range size restrictions. These factors can be influenced by human and ecological impacts like climate, resource availability, genetic diversity, and adaptive capacity (Wiegand, 2020). However, it is important to note that some species may be locally rare but abundant on a larger scale (Violle et al., 2017).

There are three main reasons as to why plants can become rare: human impacts, plants in the edge of their range, and evolutionary factors. Human impacts on plant species can include habitat loss like dredging, deforestation and construction along with poaching. Some species have spiritual ties to them, making them a target for traditional medicine, luxury goods, or ornamental decorations (Dee, 2019). When plant species are at the edge of their predicted range, they can be considered rare in that area due to the lack of prevalence. Overall, they are characterized by the variability in population, genetic differences, decreased abundance, and lack in fitness of the species (Sexton, 2009). Range size of a species helps inform management decisions about species because of its relationship with rarity and extinction risk in that area (Sheth, 2022). As for rarity of plants due to natural causes, it can be because of competition, disease, herbivory, loss of mutualistic relationships, small habitats, and introduction of new species. When new species in an area have invasive characteristics, they can outpace a species or even hybridize with it depending on species type. Hybridization can promote extinction by reducing the original population (Levin, 1996).

Rare plant surveys are conducted to determine the presence or absence of species in a designated area (Fertig, 2020). Plant surveys are important for the conservation of plant species and natural preserves because without knowing what species are present in a certain area, it is difficult to preserve them. Rare plant surveys can be used in biodiversity conservation, environmental monitoring, research, and encouraging community involvement (Chytrý et al., 2011). Since rare species have many important attributes, they contribute to the importance of surveys that focus on those species.

The objective of this study was to complete a rare plant survey and generate a plant species list, including both vascular plants and bryophytes, for the Devil's Punchbowl in Menomonie, WI. Another goal was to determine the community types present in the area using the species found during the survey in order to better understand the general ecology of the area. Plant species rarity according to the Wisconsin Natural Heritage Inventory working list (Bleser, 2023) and coefficient of conservatism were assessed in order to determine the quality of the flora in the Devil's Punchbowl.

Methods

Site Description

The Devil's Punchbowl is located just outside Menomonie in Dunn County, WI (Figure 1). In 1961, the Town of Menomonie took the title of the Devil's Punchbowl before deeding it over to Dunn County. In 1990, Dunn County gave the property to the UW-Stout Foundation. The current owner, the Landmark Conservancy, was gifted the Devil's Punchbowl in 1998. Since their ownership, they have built stairways into the preserve, rock walls for the parking area, and planted a native prairie. The most recent renovation is the construction of the new stairway that was fundraised for in 2021 (Landmark Conservancy, 2023). At the site, there is a 45-foot waterfall with a perennial stream and two trails on the three-acre property. The hydrology and geology of this site create niche microhabitats that can affect the vegetation. The geology includes stunning cliff faces that were carved by glaciers and sandstone bedrock with seepage springs at the contact between the Wonewoc and Eau Claire formations (Patterson & Brown, 1988; Kuchta, personal communication). Soil types are likewise sandy, with the Plainfield Sand and Kevilar Sandy Loam dominating the site (USDA, 2023). The site is also located near the Tension Zone of vegetation in Wisconsin, making it possible for some species to be just outside of their range and create unique mixed plant communities (Curtis, 1959).

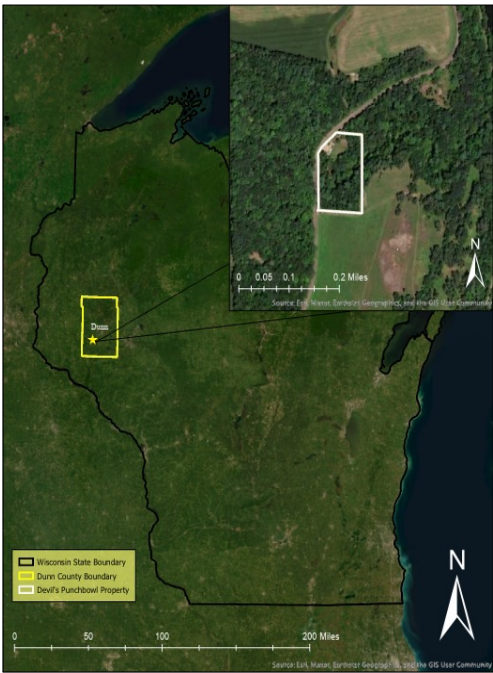


Figure 1. Location of the Devil's Punchbowl, a 3-acre preserve in Dunn County, Wisconsin (Esri 2023).

This area is believed to be the most visited nature preserve in Dunn County. There is a wide variety of habitats in the preserve, due to its large topographic diversity. Rare snails have been found there (Kuchta, unpublished data), indicating the possibility of rare plants. In addition, the site may be a refugia for non-vascular bryophytes that thrive in cool, moist microclimates (Pope, 2016). However, since the Devil's Punchbowl is a small property with high visitor traffic it may not be able to sustain rare plant species (Landmark Conservancy, 2023).

Species Inventory

Plants mature and produce fruits and flowers at varying times over the season. In order to capture this seasonal variability, the site was surveyed each week from 10 May 2022 through 25 August 2022. We walked through the different ecological communities present at the Devil's Punchbowl, inspecting different microhabitats that might hold unique species. The plant communities were identified using Wisconsin's Department of Natural Resources natural community lists (Bleser, 2023) and compared it to our own flora lists to identify smaller communities within the Devil's Punchbowl. Each walk was specifically aimed at areas where high plant diversity would be expected. We carefully investigated any new wildflower or grass that had started to bloom along with any mosses and liverworts that had new growth or reproductive structures.

When collecting a specimen, the plant species name was recorded if known, the date, and a description of the area in which it was found in to be later identified in the herbarium lab. Voucher specimens were identified and preserved for addition to the UW-Stout Herbarium (UWST) collection. Vascular plant nomenclature follows the Wisconsin State Herbarium (2022) and bryophyte nomenclature follows McKnight et al. (2013) for mosses and Pope (2016) for liverworts. Species lists were then compared to the Wisconsin Natural Heritage Inventory working list and county records from the Flora of Wisconsin to determine rarity (Bleser, 2023; Wisconsin State Herbarium, 2022).

Moss Identification

Moss and liverwort species identification took place at the herbarium lab at UW-Stout. The first step to proper identification of mosses was to determine the growth form: acrocarp or pleurocarp. An acrocarp has three key traits: simple stems, capsules arising from the stem tip, and typically upright standing stems. Pleurocarps have stems that branch freely, capsules that arise midstem, and typically trail along the ground (McKnight et al., 2013). Other features that were important within moss identification included leaf shape and midrib presence. After the end of the season, the moss species identification was confirmed by Dr. Joseph Rohrer, emeritus professor of Biology at UW-Eau Claire. Guides were also used to identify the common microhabitat in which it is found, including substrate and saturation conditions (McKnight et al., 2013).

Analysis

Plant species found at the Devil's Punchbowl were assigned to vascular plant communities using the Wisconsin's Natural Communities working list (WDNR 2022). Mosses were assigned to typical microhabitats using McKnight et al. (2013). By sorting out these species, we were able to determine which Wisconsin natural community types are present in the Devil's Punchbowl. Coefficient of conservatism (C of C) and native or non-native status was determined by using the Online Virtual Flora of Wisconsin (Wisconsin State Herbarium, 2022) or the Michigan Flora website (University of Michigan, 2022). C of C measures how faithful a species is to their natural plant community. Plant values range from 0-10 and differ regionally due to vegetation having different impacts in locations. Coefficients with a value of 0 show that a species is "weedy" and shows no specificity of habitat preference. A value of 10 means that the species can only be found within their natural plant community and never outside of it. They are sensitive to even the mildest forms of habitat degradation (Rooney and Rogers, 2002).

Results

Eight ecological communities from the Wisconsin Natural Communities list (WDNR, 2022) are present in the Devil's Punchbowl (Table 1). The most common communities at the site were northern and southern mesic forests. The least common natural community was a dry prairie. Since the larger prairie was originally planted, it had characteristics of a mesic, sand, and dry prairie along with surrogate grassland.

Community Type	# of plants from Devil's Punchbowl in the plant community description
Northern Mesic Forest	12
Southern Mesic Forest	12
Northern Dry-Mesic Forest	10
Southern Dry-Mesic Forest	9
Central Sands Pine-Oak Forest	9
Dry Cliff	7
Mesic Prairie	6
Sand Prairie	6
Surrogate Grassland	6
Moist Cliff	5
Dry Prairie	3

Table 1. Dominant plant communities found based upon the number of plants in common with the Natural Plant Communities of Wisconsin working list description (WDNR 2022).2023).

78.9% of the vascular species were native, and 6.7% were invasive or aggressive (Table 2). The highest coefficient of conservatism observed was 9 for *Chrysosplenium americanum* Schwein. ex Hook., *Polypodium virginianum* L., and *Symphytotrichum prenanthoides* (Muhl. ex Willd.) G.L. Nesom. Forty-six species had a coefficient of conservatism of zero (Appendix 2). Of the 206 different species found, the average coefficient of conservatism was 3.80. Excluding non-native and invasive species, the average coefficient of conservatism is 4.70. We also found 12

different fern species and three clubmosses (*Dendrolycopodium dendroideum* (Michx.) A. Haines, *Huperzia lucidula* (Michx.) Trevis., and *Spinulum annotinum* (L.) A. Haines). The clubmosses were limited to populations of 1-5 individuals.

Native Status	Count	Percent of Total
Native	165	78.9
Native, Potentially invasive	5	2.4
Introduced, Naturalized or Escaped	17	8.1
Introduced, Potentially invasive	8	3.8
Invasive	14	6.7

Table 2. Number of plant species categorized by native status – native, introduced, naturalized, or invasive. (University of Wisconsin – Madison, University of Michigan).

The largest number of bryophyte species was found on rotten log and stump microhabitat. The next most species-rich microhabitat were mosses of disturbed areas. In total, there were nine different bryophyte microhabitats (Table 3). We found 25 different species of mosses and four different species of liverwort. None of these species are considered rare or uncommon in Wisconsin.

Microhabitat Type	# of bryophytes in the microhabitat description
Rotten Logs and Stumps	7
Disturbed Areas	6
Wet Rocks	5
Tree Base	3
Rich Woods	2
Rocks	2
Tree Bark	2
Swamps, Marshes, and Fens	1
Damp Soil; Streams and Seeps	1

Table 3. Dominant bryophyte microhabitats found based upon the number of bryophytes in common with the habitat list. (McKnight et al 2013).

Notably, there were 13 different fern species present in the Devil's Punchbowl Preserve. There were also three clubmosses that were found. Each of them had a total population of 1-5 individuals. Two of those species have not been documented in Dunn County as of yet. It is unknown if it is due to lack of sampling effort, edge of range, or rarity in this area.

Discussion

The Devil's Punchbowl is a unique, small preserve with a high species density (number of species per area). Environmental heterogeneity is a driving factor that affects the species richness of a site; in the case of the Devil's Punchbowl, there are many different natural communities present, which is likely driving the high species

richness there (Cain, 2014; Table 1; Table 3). Since Dunn County is located in central Wisconsin, there are species from both the northern and southern ecological provinces, indicating that this site is located along the tension zone (Curtis, 1959; WI DNR, 2015). About 10% of the 2,640 total plant species recorded in Wisconsin are in this 3-acre preserve. However, we found no Natural Heritage Inventory-listed rare species found at the Devil's Punchbowl during this plant survey, possibly due to the small acreage and the fact that it is a highly popular tourist destination with heavy trampling (Landmark Conservancy, 2023). It is important to conserve small areas that have high species richness (Stein et al., 2014).

4.45% of the 877 recorded invasive species in Wisconsin are also prevalent at the Devil's Punchbowl (Wetter et al. 2001). Most of the low coefficient of conservatism value species were non-native and/or invasive. Not only do these species lower the site's coefficient of conservatism, but they also threaten the species at the site with higher values (Rooney and Rogers, 2002). When surveying, *Alliaria petiolata* (M. Bieb.) Cavara & Grande was pulled and removed from the site. To help better protect the Devil's Punchbowl's biological diversity and conservation, more efforts should be made to get rid of these invasive and aggressive species.

Despite the lack of rare species, the Devil's Punchbowl still provides valuable contributions to plant conservation in the area. With over 200 vascular plant species and over 30 bryophyte species (Appendix 1), this small preserve holds a substantial portion of Wisconsin's recorded species (Bleser, 2023). The bryophyte habitat of the Punchbowl has a dominant species of liverworts – specifically *Conocephalum salebrosum* Szweyk., Buczkowska & Odrzykoski and has a diversity of different moss habitats. Some mosses grew on the cliff face in dripping water conditions. However, the moss expert Dr. Joe Rohrer was surprised to see a species of *Rhyncostegium* spp., not because it was rare, but because it would normally be in a more submerged area (J Rohrer, pers. comm.). There were a few species that are not found locally elsewhere like *Clintonia borealis* (Aiton) Raf., *Circaea montana* L., and twelve different species of ferns including *Polypodium virginianum*, *Cystopteris bulbifera* (L.) Bernh., and *Phegopteris connectilis* (L.) Slosson.

The small populations of the three clubmoss species are possibly at risk of local extinction due to small population size. *Dendrolycopodium dendroideum* and *Spinulum annotinum* have never been documented in Dunn County before, although we are unsure if this is due to rarity or lack of sampling effort. Ferns thrive in specific conditions, which shows that the Devil's Punchbowl has the specific microclimates necessary to support them. They have the ability to survive in low-light conditions, high humidity, high tolerance of substrates, and limited competition due to their ability to grow on cliffsides (Page, 2002).

In comparison to our observed coefficient of conservatism of 3.80, Rooney and Rogers (2002) found a mean C of C of 5.63 when sampling undisturbed forest in Michigan's Upper Peninsula. In terms of sampling, the factors that affect this coefficient are timing, effort, and accuracy. However, conservatism does not always determine rarity, because some species can be highly faithful to widespread habitats (Bernthal, 2003). We suspect the low C of C is due to the level of disturbance this site has. The parking lot, roadside, and small preserve size all contribute to the C of C at the Devil's Punchbowl. Being close to the roadside can introduce more

undesirable species that thrive in disturbed locations and eventually spread into the small preserve (Jakobsson et al., 2018).

Future surveys should occur every 5-10 years to assess species loss. To further protect the Devil's Punchbowl, new fences should be installed to prevent people from going under or over them and protect the soil and rock from further erosion. It would also help to bring awareness of the importance of the Devil's Punchbowl and encourage visitors to stay on the trails to protect the Punchbowl, plant species, soil, and themselves.

References

- Bernthal, T. W. (2003). *Development of a Floristic Quality Assessment Methodology for Wisconsin*. Wisconsin Department of Natural Resources. Retrieved October 17, 2022, from <https://dnr.wi.gov/topic/Wetlands/documents/FQAMethodWithAcknowledgements.pdf>.
- Bleser, J. (2023). *Wisconsin Natural Heritage Inventory Working List*. NHI Working List. Retrieved October 17, 2022, from <https://dnr.wisconsin.gov/sites/default/files/topic/NHI/NHIWorkingList.pdf>.
- Cain, M. L., Bowman, W. D., & Hacker, S. D. (2014). *Ecology*. Sinauer Associates, Inc.
- Chytrý, M., Schaminée, J. H., & Schwabe, A. (2011). Vegetation survey: a new focus for Applied Vegetation Science. *Applied Vegetation Science*, 14(4), 435-439.
- Curtis, J. T. (1959). *The Vegetation of Wisconsin: An ordination of plant communities*. University of Wisconsin Press.
- Dee, L. E., Cowles, J., Isbell, F., Pau, S., Gaines, S. D., & Reich, P. B. (2019). When Do Ecosystem Services Depend on Rare Species? *Trends in Ecology & Evolution*, 34(8), 746–758. <https://doi.org/10.1016/j.tree.2019.03.010>.
- Esri. "Imagery" [basemap]. Scale Not Given. "World Imagery". Jan 12, 2023. <https://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9>. (Jan 25, 2023).
- Fertig, W. (2020). *Guidelines for Conducting Rare Plant Surveys*. Washington Department of Natural Resources. Retrieved October 17, 2022, from https://www.dnr.wa.gov/publications/amp_nh_survey_guidelines.pdf.
- Jakobsson, S., Bernes, C., Bullock, J. M., Verheyen, K., & Lindborg, R. (2018). How does roadside vegetation management affect the diversity of vascular plants and invertebrates? A systematic review. *Environmental Evidence*, 7(1), 1-14.
- Landmark Conservancy. (2023). *Punchbowl Campaign*. Landmark Conservancy. Retrieved October 17, 2022, from <https://landmarkwi.org/punchbowl-campaign/#open-overlay>.
- Landmark Conservancy WI. (2023). *A Brief History of the Devil's Punchbowl*. Landmark Conservancy. Retrieved October 17, 2022, from <https://landmarkwi.org/a-brief-history-of-the-devils-punchbowl/>.
- Levin, D. A., Francisco-Ortega, J., & Jansen, R. K. (1996). Hybridization and the Extinction of Rare Plant Species. *Conservation Biology : the Journal of the Society for Conservation Biology*, 10(1), 10–16. <https://doi.org/10.1046/j.1523-1739.1996.10010010.x>.
- McKnight, K. B., Rohrer, J. R., Ward, K. M. K., & Perdrizet, W. J. (2013). *Common mosses of the northeast and Appalachians*. Princeton University Press.
- Page, C. N. (2002). Ecological strategies in fern evolution: a neopteridological overview. *Review of palaeobotany and palynology*, 119(1-2), 1-33.
- Patterson, & Brown. (1988). *Bedrock Geology of Wisconsin*. Map, Madison, WI; Wisconsin Geological and Natural History Survey.
- Pope, R. (2016). *Mosses, Liverworts, and Hornworts: A Field Guide to Common Bryophytes of the Northeast*. Comstock Publishing Associates.

- Rooney, T. P., & Rogers, D. A. (2002). The Modified Floristic Quality Index. *Natural Areas Journal*, 22(4), 340–344.
- Sexton, J. P., McIntyre, P. J., Angert, A. L., & Rice, K. J. (2009). Evolution and Ecology of Species Range Limits. *Annual Review of Ecology, Evolution, and Systematics*, 40(1), 415–436. <https://doi.org/10.1146/annurev.ecolsys.110308.120317>.
- Sheth, S. N., Morueta-Holme, N., & Angert, A. L. (2020). Determinants of geographic range size in plants. *The New Phytologist*, 226(3), 650–665. <https://doi.org/10.1111/nph.16406>.
- Stein, A., Gerstner, K., & Kreft, H. (2014). Environmental heterogeneity as a universal driver of species richness across taxa, biomes and spatial scales. *Ecology Letters*, 17(7), 866–880.
- University of Michigan Herbarium. (2023). *University of Michigan Herbarium Search*. Search - Michigan Flora. Retrieved October 17, 2022, from <https://michiganflora.net/search.aspx>.
- USDA. (2023). Web Soil Survey. Retrieved January 11, 2023, from <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>.
- Violle, C., Thuiller, W., Mouquet, N., Munoz, F., Kraft, N. J., Cadotte, M. W., ... & Mouillot, D. (2017). Functional rarity: the ecology of outliers. *Trends in Ecology & Evolution*, 32(5), 356–367.
- Wetter, M. A., Cochrane, T. S., Black, M. R., Iltis, H. H., & Berry, P. E. (2001). *Wisconsin State Herbarium – Department of Botany – UW–Madison*. University of Wisconsin - Madison Herbarium. Retrieved October 17, 2022, from <https://herbarium.wisc.edu/wp-content/uploads/sites/205/2017/05/WIChecklist2001.pdf>.
- Wiegand, T. P., Gentry, B., McCoy, Z., Tanis, C., Klug, H., Bonsall, M. B., & Boyd, J. N. (2020). Visualizing connectivity of ecological and evolutionary concepts—An exploration of research on plant species rarity. *Ecology and Evolution*, 10(17), 9037–9047. <https://doi.org/10.1002/ece3.6633>.
- Wisconsin Department of Natural Resources (DNR). (2001). *Wisconsin's Biological Forest Resources*. Forest Legacy Planning Chapter 3. Retrieved October 17, 2022, from <https://dnr.wisconsin.gov/sites/default/files/topic/ForestPlanning/Chapter03.pdf>.
- Wisconsin Department of Natural Resources. (2015). *Assessment of current conditions*. Chapter 2 in *The Ecological Landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management*. Wisconsin Department of Natural Resources, PUB-SS-1131C 2015, Madison.
- Wisconsin Department of Natural Resources. (2023). *Wisconsin's Natural Communities*. Natural Communities of Wisconsin - Wisconsin DNR. Retrieved October 17, 2022, from <https://dnr.wi.gov/topic/endangeredresources/communities.asp>.
- Wisconsin State Herbarium. (2023). *Online Virtual Flora of Wisconsin*. Online Virtual Flora of Wisconsin Home. Retrieved October 17, 2022, from <https://wisflora.herbarium.wisc.edu/index.php>.

Appendices

Family	Latin Name	Common Name	Bryophyte Type
Adelanthaceae	<i>Jamesoniella autumnalis</i> (D.C.) Steph.	A liverwort	Liverwort
Amblystegiaceae	<i>Hygroamblystegium varium</i> (Hedw.) Monk.	Tangled Thread moss	Pleurocarp
Anomodontaceae	<i>Anomodon attenuatus</i> (Hedw.) Hub.	Poodle moss	Pleurocarp
	<i>Anomodon minor</i> (Hedw.) Furrn.	Rounded Tongue moss	Pleurocarp
	<i>Anomodon rostratus</i> (Hedw.) Schimp.	Yellow Yarn moss	Pleurocarp
Bartramiaceae	<i>Bartramia pomiformis</i> Hedw.	Apple moss	Acrocarp
Brachytheciaceae	<i>Brachythecium</i> spp. Schimp.	Foxtail moss	Pleurocarp
	<i>Brachythecium oxycladon</i> (Brid.) A. Jaeger	Pleated Foxtail moss	Pleurocarp
	<i>Brachythecium rivulare</i> Schimp.	River Foxtail moss	Pleurocarp
	<i>Rhyncostegium</i> spp. Bruch & Schimp.	Rhyncostegium moss	Pleurocarp
Bryaceae	<i>Gemmabryum caespiticium</i> (Hedw.) J.R. Spence	Handbell moss	Acrocarp
Bryopsida	<i>Plagiommium ciliare</i> (C. Mull.) T. Kop.	Saber Tooth moss	Acrocarp
	<i>Plagiommium cuspidatum</i> (Hedw.) T. Kop.	Baby Tooth moss	Acrocarp
Climaciaceae	<i>Climacium dendroides</i> (Hedw.) F. Weber & D. Mohr	Palm Tree moss	Pleurocarp
Conocephalaceae	<i>Conocephalum salebrosum</i> Szwedk., Buczkowska & Odrzykoski	Snakeskin liverwort	Liverwort
Ditrichaceae	<i>Ceratodon purpureus</i> (Hedw.) Brid.	Purple moss	Acrocarp
Entodontaceae	<i>Entodon cladorrhizans</i> (Hedw.) C. Mull.	Flat Glaze moss	Pleurocarp
Geocalyceae	<i>Geocalyx graveolens</i> (Schrad.) Nees	A liverwort	Liverwort

Appendix 1. Bryophyte species found in Devil's Punchbowl and their bryophyte type (McKnight et al 2013).

Family	Latin Name	Common Name	Coefficient of Conservatism
Adoxaceae	<i>Viburnum acerifolium</i> L.	Maple-Leaved Viburnum	7
Amaranthaceae	<i>Chenopodium</i> spp. L.	Goosefoot	0
Amaryllidaceae	<i>Allium cernuum</i> Roth	Nodding Wild Onion	7
Anacardiaceae	<i>Allium tricoccum</i> Sol.	Ramps	6
	<i>Toxicodendron rydbergii</i> (Small ex Rydb.) Greene	Poison Ivy	2
Apiaceae	<i>Cryptotaenia canadensis</i> (L.) DC.	Honewort	4
	<i>Daucus carota</i> L.	Queen Anne's Lace	0
	<i>Osmorhiza longistylis</i> (Torr.) DC.	Smooth Sweet-Cicely	4
	<i>Pastinaca sativa</i> L.	Wild Parsnip	0
	<i>Sanicula marilandica</i> L.	Black Snakeroot	5
	<i>Apocynum androsaemifolium</i> L.	Spreading Dogbane	2
	<i>Asclepias syriaca</i> L.	Common Milkweed	1
Araceae	<i>Asclepias tuberosa</i> L.	Butterfly-Weed	6
	<i>Arisaema triphyllum</i> (L.) Schott	Jack-in-The-Pulpit	5
	<i>Lemna</i> spp. L.	Duckweed	4
	<i>Symplocarpus foetidus</i> (L.) Salisb. ex W.P.C.Barton	Skunk Cabbage	8
Araliaceae	<i>Aralia nudicaulis</i> L.	Wild Sarsaparilla	6
	<i>Aralia racemosa</i> L.	Spikenard	7
Aristolochiaceae	<i>Asarum canadense</i> L.	Wild Ginger	7
Asparagaceae	<i>Asparagus officinalis</i> L.	Asparagus	0
	<i>Maianthemum canadense</i> Desf.	Canada Mayflower	5
Asteraceae	<i>Maianthemum racemosum</i> (L.) Link	False Solomon's Seal	5
	<i>Achillea millefolium</i> L.	Yarrow	1
	<i>Ageratina altissima</i> (L.) R.M.King & H.Rob.	White Snakeroot	4
	<i>Ambrosia artemisiifolia</i> L.	Ragweed	0
	<i>Ambrosia trifida</i> L.	Giant Ragweed	0
	<i>Arctium minus</i> (Hill.) Bernh.	Burdock	0
	<i>Bidens connata</i> Muhl. Ex Willd.	Purple-Stemmed Tickseed	6
	<i>Bidens frondosa</i> L.	Common Beggar-Ticks	1

Appendix 2. Vascular plant total species list for the Devil's Punchbowl and their coefficient of conservatism (Wisconsin State Herbarium 2022; University of Michigan 2022).

Black Robes: God's Patriots that Prepared America for Independence

DJ Walker¹

Senior, Applied Social Science: History and Politics Concentration

Faculty Advisor: Dr. Christopher Marshall

Abstract

The various causes of the American Revolution have been studied for centuries by numerous scholars. Of the many causes, the role of colonial clergy, while once studied regularly, has not received the same level of academic attention in recent years. Many ministers are noted for the direct impact they had on intellectually preparing colonial Americans for the American Revolution. John Wise, in the late 17th and early 18th centuries, preached sermons against oppressive royal governance on topics such as the principle that taxation without representation is tyranny. These political sermons would captivate colonial thought in the proceeding decades. Another clergyman of colonial America was George Whitefield. Whitefield traveled the colonies during the First Great Awakening, preaching to the colonists on the importance of unification and in the belief of God with his "Father Abraham Sermons." The unification of faith would later extend into the political realm through the creation of a uniquely American identity. A third major figure was Jonathan Mayhew. His sermon on unlimited submission paved the way for the colonial population, who were regular church attendees, to have a Biblical basis for their rebellion against the British Crown. These ministers laid the foundation for a colonial population to be prepared for a political and military revolution.

Introduction

Historians often trace the ideas that inspired American independence back to English Constitutionalism, especially the 1688 English Bill of Rights and Enlightenment thinkers such as John Locke and Baron de Montesquieu. The Enlightenment and English constitutionalist heritage certainly played a role in lighting the torch for revolution in America; however, the sermons and actions of colonial ministers also greatly contributed to the eventual independence of the United States. President Calvin Coolidge acknowledged the unique influence ministers had in framing a colonial revolution during his public address in Philadelphia on the 150th anniversary of the Declaration of Independence:

The great apostle of this movement was the Rev. John Wise, of Massachusetts... Wise published a treatise entitled 'The Church's Quarrel Espoused' in 1710, which was amplified in another publication in 1717. In it he dealt with the principles of civil government. His works were reprinted in

1772 and have been declared to have been nothing less than a textbook of liberty for our Revolutionary fathers.²

While to the untrained eye, President Coolidge's speech may appear to be an obscure reference to a minor element in America's journey toward independence, the ensuing evidence will show a very different historical reality. As historian Alice Baldwin noted in her analysis of the place of religion in the founding, "The Constitutional Convention and the written Constitution were the children of the pulpit."³

While increasingly obscured in modern thought, the efforts of several ministers in Colonial America certainly contributed to the evolution of colonial America that had been reliant upon the British Crown from adversaries during the French and Indian War to a nation that fought for, won, and cemented its independence from Great Britain. The linkage between the clergy and revolution is no better illustrated than by their derisive reference as the Black Robed Regiment, by none other than the British themselves.⁴ Three ministers in particular, the Rev. John Wise, the Rev. George Whitfield, and the Rev. Jonathan Mayhew, were instrumental in bringing about a change in thinking in the American colonies; these changes in colonial thought were stimulated by British government actions following the 1763 conclusion to the French and Indian War.

Reverend John Wise

Jonathon Wise was a congregational minister in the small town of Ipswich Massachusetts in the late 17th and early 18th centuries. Congregationalism, which stemmed from the Puritan tradition, was the official denomination of Massachusetts Colony. During Wise's tenure, Edmund Andros arrived from England to be the governor of New England in its entirety. Upon assuming office, Andros attempted to eliminate the independent charters of multiple New England colonies (i.e., Massachusetts, Plymouth, Connecticut), and create a single royal colony-The Dominion of New England.

Wise became a leading figure in fighting Andros from his place at the pulpit,⁵ preaching on topics that would become some of the most recognizable principles and ideas shortly before and during the American Revolutionary War. The American Revolution Era refrain, "No taxation without representation" was stimulated by the passage of the Stamp Act in 1765; however, this phrase did not make its introduction at this juncture in history. The sentiment of this right was seeded in the colonial conscience much earlier than was the Stamp Act. The historical record relates that Wise preached taxation without representation is tyranny."⁶ In addition, Wise is recorded to have preached and discussed other ideas such as, "Consent of the

² "Address at the Celebration of the 150th Anniversary of The Declaration of Independence in Philadelphia, Pennsylvania," *The American Presidency Project*, July 5, 1926.

³ Alice Baldwin, *The New England Clergy and the American Revolution* (Durham: Duke University Press, 1928), 134.

⁴ Peter Oliver, *Peter Oliver's Origin & Progress of the American Rebellion*, ed. Douglas Adair and John Schutz (San Marino California: The Huntington Library, 1961), 29, 41-45.

⁵ 4. John Langdon Sibley, *Biographical Sketches of Graduates of Harvard University in Cambridge, Massachusetts*, vol 2 (Cambridge: Charles William Sever, 1881), 429-431.

⁶ David Otis Mears, *Oberlin Lectures of 1829: The Pulpit and the Pews* (Oberlin College: Edward G. Goodrich, 1892), 87.

People"⁷ and "it follows as a command of the law of nature, that every man esteem and treat another as one who is naturally his equal."⁸ These sentiments, if not actual quotations, became rallying cries for independence amidst the upheaval between the colonists and Great Britain in the 1760s and 1770s.

The similarity between these phrases and principles that Wise preached and those which were espoused by the revolutionary generation cannot be viewed as unconnected and/or separate (barring a fantastical belief in historical coincidence). In fact, it is not a coincidence that phrases that became associated with the revolutionary generation were based on fundamental principles taught by Wise in the pulpit generations prior to the Revolution. Rather, those principles were recognized by colonists as speaking important truths related to the emerging struggle against Great Britain.

In the early 1770s the tension between the American colonies and Great Britain was building up to its peak. Following the March 1770 Boston Massacre, an uneasy tension existed between the British government and the colonies, especially for those living in Boston, Massachusetts. It was at this moment in history that certain colonists, those who were beginning to consider how to rally the general populace to the cause against Great Britain, considered strategies to increase broad popular support for rebellion against their home country. This is where the familiarity between Wise's writings and many of the sayings and beliefs that people have come to associate with the American Revolution came together.

In 1772, colonists reprinted two of Wise's works.⁹ These works had been originally published in 1710 and 1717 and contained many of the arguments being utilized against Great Britain. The first edition was so popular that it resulted in "Two editions soon exhausted."¹⁰ The popularity of Wise's works indicates its resonance with the colonial audience. With the lengthy and challenging printing process of the 18th century, the demand must have been extraordinary for the printers to run a second edition.

There was a correlation between what Wise was preaching generations earlier and the shaping of beliefs of many of the colonists in the fight against Great Britain. For example, historian Benjamin Franklin (B.F.) Morris stated, "Some of the most glittering sentences in the immortal Declaration of Independence are almost literal quotations from this essay of John Wise... It was used as a political textbook in the great struggle for freedom."¹¹ This illustrates the status that 19th century American historians awarded to the influence of Wise, and the consideration, by historians, of the influence Wise passed onto the founding generation.

A strong case exists that Wise's works inspired some of the greatest lines in the Declaration of Independence—lines which inspired the American colonists to make a clean break from Great Britain. Wise received his inspiration for writing what

7 John Wise, *A Vindication of the government of New-England churches: drawn from antiquity, the light of nature, Holy Scripture, its noble nature, and from the dignity Divine Providence has put upon it* (Boston: John Boyes, 1772), 5.

8 Wise, 26.

9 Claude H. Van Tyne, *The Causes of the War of Independence* (Boston and New York: Houghton Mifflin Company, 1922), 357.

10 Van Tyne, 357.

11 Benjamin Franklin Morris, *Christian Life and Character of the Civil Institutions of the United States: Developed in the Official and Historical Annals of the Republic* (Philadelphia: G. W. Childs, 1864), 341.

was very revolutionary in his time before it entered common parlance from some knowledge source. As a minister of the Gospel, Wise certainly received inspiration from the Bible and God, and that must be acknowledged as a guide for the stand he took and the inspiration he bequeathed to later American colonists. Not for nothing, Ipswich is known to be a "Birthplace of American Independence."¹²

Reverend George Whitefield

In the 1730s, the First Great Awakening began to sweep through the colonies. The Great Awakening was partly a response to the state of religion in the American colonies, described by Rev. Samuel Blair as one where, "Religion lay, as it were, dying and ready to expire its last breath of life in this part of the visible church."¹³ This cessation of religion was a radical departure from the strict Puritan church ethos of the early New England colonists in the 17th century.

One of the more famous ministers associated with the First Great Awakening was the Rev. George Whitefield, an Anglican minister of a Methodist strain. For thirty-four years, Whitefield traversed the American colonies and Europe, preaching over 18,000 sermons and attracting massive crowds.¹⁴ Through these innumerable speaking engagements, Whitefield had an unprecedented opportunity to impact the American colonies on a range of issues due to the sheer number of American colonists who heard him speak. It is estimated that 80% of people living in the American colonies heard him preach, a stunning feat in an era before mass media.¹⁵ How he used this influence is of the utmost importance when considering the impact he would have on the future American Revolution.

Whitefield's impact can be found in the way the seeds of religious unification he planted transcended the old political separatism in the colonies. This was at a time when each of the thirteen colonies viewed themselves as separate countries, not unlike the German principalities of the 18th and 19th centuries, with separation of everything from money, taxes, trade, etc. This political, economic, and social disunion could also be found in the religious differences of the separate colonies.

Colonies often had their own distinct official or favored religious denomination; for example, Virginia was Anglican, and Massachusetts was Congregational. Religious limitations on the free exercise for nonofficial denominations occurred in some colonies, especially Virginia, against religious minorities; for example, "But in many others, alarmed by the rapid increase of the Baptists, the men in power, trained every penal law in the Virginia Code, to obtain ways and means, to put down their disturbers of the peace, as they were now called."¹⁶ The denominational divide posed a risk that the colonies would struggle to unite against Britain in the event of a future conflict. This was a situation that required a remedy: Rev. Whitefield,

¹² J.H. Burnham, "The Birthplace of American Independence, 1687." *The Journal of American History* 9, no. 1 (1915): 444.

¹³ Joseph Tracy, *The Great Awakening: A History of the Revival of Religion in the Time of Edwards and Whitefield* (Boston: Charles Tappan, 1845), 26, Quoting Rev. Samuel Blair in 1744.

¹⁴ James G. Wilson and John Fiske, *Appleton's Cyclopedia of American Biography*, Vol 6 (New York: Appleton & Sons, 1889), 477-478.

¹⁵ Dave Schleck, "CW to Recreate Visit of Famous Preacher," *Daily Press*, August 7, 2021.

¹⁶ Robert B. Semple, *A History of the Rise and Progress of the Baptists in Virginia* (Richmond: O'Lynch, 1810), 14.

This is the point in the American story when Whitefield came into view; he began to preach his then famous "Father Abraham" sermons. These sermons were an attempt to break down the barriers between denominations. He approached the issue the best way he knew how—by returning to the basic and fundamental belief system that all Christians at the time possessed rather than becoming enmeshed in doctrine and theology. Whitefield preached widely throughout the colonies. Many colonists, including some Founding Fathers, heard Whitefield's most famous type of sermon: The Father Abraham Sermons. John Adams wrote in a letter to Thomas Jefferson extolling Whitefield's sermon:

He began: "Father Abraham," with his hands and eyes gracefully directed to the heavens (as I have more than once seen him): "Father Abraham, whom have you there with you? Have you Catholics? No. Have you Protestants? No. Have you Churchmen? [Anglicans]. No. Have you Dissenters? [Congregationalists]. No. Have you Presbyterians? No. Quakers? No. Anabaptists? [Amish and Mennonites]. No. Whom have you there? Are you alone? No. My brethren, you have the answer to all these questions in the words of my next text. He who feareth God and worketh righteousness, shall be accepted of Him" [Acts 10:35].¹⁷

Whitefield's words speak for themselves. Unity based on a shared belief in the same God, without worries as to specific faction or party of Christianity, was the order of the day when Whitefield came to town. This message of unity was heard by other Founding Fathers such as Benjamin Franklin.¹⁸ The "Father Abraham" sermons would play a critical role in unifying the colonies in general, and immediately preceding the American Revolution there would be one instance where this sentiment would be critical in helping the Founding Fathers birth a new country.

At the first Continental Congress, there were pervasive divides among the delegates about fundamental issues facing the American colonies. Some, like Samuel Adams, were clamoring for a break from Britain, but many were not prepared to go that far in 1774. When the delegates first came together to discuss what their response to Britain should be, John Adams wrote:

When the Congress first met, Mr. [Thomas] Cushing [of Massachusetts] first made a motion that it should be opened with prayer.¹⁹ It was opposed by Mr. Jay of New York and Mr. Rutledge of South Carolina because we were so divided in religious sentiments—some Episcopalians, some Quakers, some Anabaptists, some Presbyterians, and some Congregationalists—that we could not join in the same act of worship.²⁰

It was not a matter of distaste for religion that prevented the motion from being acted upon; rather, it was the same problem Whitefield had addressed in his "Father Abraham" sermons. This precarious moment in the history of the First Continental Congress found its resolution in Samuel Adams, the man known as "The Father of American Revolution."²¹

¹⁷ Thomas Jefferson, *The Writings of Thomas Jefferson*, vol 14, ed. Andrew A. Lipscomb (Washington DC: The Thomas Jefferson Memorial Association, 1905), 49-20, from John Adams on December 3, 1813.

¹⁸ "Benjamin Franklin on Rev. George Whitefield, 1739," National Humanities Center.

¹⁹ John Adams, *Letters of John Adams Addressed to His Wife*, vol 1, ed. Charles Francis Adams (Boston: Charles C. Little and James Brown, 1841), 23-24, to Abigail Adams on September 16, 1774.

²⁰ Adams, 23-24.

²¹ See Mark Puls, *Samuel Adams Father of the American Revolution* (New York: Macmillan, 2006).

Adams considered the predicament over the motion, and determining that he could lead by example as a Bostonian and a Congregationalist, he announced that because he was a stranger and not knowledgeable of the Philadelphia area, the local Rev. Duche, an Episcopalian (Anglican: Church of England), should say prayer for the assembly.²² Samuel Adams, as a Congregationalist, would be no flatterer of Episcopalian ministers; nonetheless he suggested Duche. This was done in an effort to apply the "Father Abraham" sermon theme to unify the delegates and allow them to work together.

Upon this confession of Adams, which showed a willingness to lead by example and unite with people of different denominations, the original motion by Mr. Cushing was approved and Duche came before the assembly.²³ The prayer that Duche prayed was powerful and according to John Adams "had an excellent effect upon everybody here."²⁴ This prayer by Duche, suggested by someone of a competing Christian denomination, helped to remove disagreement and create an atmosphere of progress in order to decide steps to oppose Great Britain.

The influence of the "Father Abraham" sermons on religious and hence political unification rested on a shared fundamental Christian ethic. In addition to the episode of the First Continental Congress, other instances recalled a similar unity at crucial and sometimes dire points in the American War for Independence. This was exemplified by the fact that Congress called the nation to a unified prayer 15 times during the Revolution.²⁵ The "Father Abraham" sermons Whitefield gave was a glue which kept disparate colonies united through difficult years.

Whitefield's calls for unification based on shared fundamental Christian orthodoxy in the decades before the War of Independence created the environment in which the colonists could work together regardless of their differences. His influence can be traced through the decade when uncertainty in the outcome of the war was a daily occurrence. It can be conceded that Whitefield's sermons, heard by so many, were an inspiration in uniting the colonies in opposition against Britain.

Reverend Jonathan Mayhew

The observation "The people made the laws, and the church made the people"²⁶ by historian David Gregg describes how the church influenced those making the laws. This assessment is strengthened by the fact that over 98% of

22 John Adams, *Letters of John Adams Addressed to His Wife*, vol 1, ed. Charles Francis Adams (Boston: Charles C. Little and James Brown, 1841), 23-24, to Abigail Adams on September 16, 1774.

23 Adams, 23-24.

24 Adams, 23-24.

25 *Journals of the continental Congress* (Washington Printing Office, 1906), 2: 87-88, "Humiliation, Fasting and Prayer," for July 20, 1775, 4:208-209, "Humiliation, Fasting and Prayer," for May 17, 1776, 6:1022, "Fasting and Humiliation," for December 11, 1776, 9: 854-855, "Thanksgiving and Praise," for December 18, 1777, 10: 229-230. "Fasting, Humiliation and Prayer," for April 22, 1778, 12:1139, "Thanksgiving and Praise," for December 30, 1778, 13:343-344, "Fasting, Humiliation and Prayer," for March 4, 1779, 15: 1191-1193, "Thanksgiving," for December 9, 1779, 16:252-253, "Fasting, Humiliation and Prayer," for April 26, 1780, 18:950-951, "Thanksgiving and Prayer," for December 7, 1780, 19:284-286, "Humiliation, Fasting and Prayer," for May 3, 1781, 22:137-138, "Fasting, Humiliation and Prayer," for April, 1782, 23:647, "Thanksgiving," for November 28, 1782 25: 699-701, "Thanksgiving," for December, 1783.

26 David Gregg, W.W. Goodrich, and Sidney H. Carney, *Makers of the American Republic* (New York: E.B. Treat and Company, 1905), 439.

colonial Americans in the founding era were Protestant, 1.9% Catholic, and the remainder being predominantly Jewish.²⁷ This indicates a connection between pastoral teachings and the civil laws and political philosophy of many influential Americans.

One clergyman in particular can be said to have had this type of influential attribute in the American colonies before the American Revolution. The Rev. Jonathan Mayhew (1720-1766), referred to as the "Father of Civil Liberty," was a Congregationalist minister in Boston beginning in the mid-18th century. Mayhew was influential in the colonies when it came to the issue of whether the colonists were duty-bound to obey the King of England if the King, at some point violated his duty as the governing authority. This influence would arise from a specific incident which helped set the framework for colonial political thought.

Mayhew became highly influential following his 1750 sermon, *A Discourse Concerning Unlimited Submission and Non-Resistance to the Higher Powers*. In this sermon, on the anniversary of the execution of King Charles I in 1649, Mayhew spoke against the idea that a people owed unlimited and unconstrained allegiance to a governing authority, regardless of any tyranny that that governing authority brought forth against the people. This sermon has been shown to have contributed to the formation of an early motto from the American Revolution "Rebellion to Tyrants is Obedience to God,"²⁸ the inspiration of which proceeded from the fountain of Mayhew's sermon.

The impact that Mayhew's preaching had on the American colonists, including Founding Fathers, is evidenced when John Adams declared:

Another gentleman, who had great influence in the commencement of the revolution, was doctor Jonathan Mayhew... This divine had raised a great reputation both in Europe and America, by the publication of a volume of seven sermons in the reign of king George the second, 1749, and by many other writings, particularly a sermon in 1750, on the thirtieth of January, on the subject of passive obedience and non-resistance.²⁹ This inducement from the pulpit initiated a great questioning of how far loyalty to tyranny may extend out of obligation to the governing authority.

Adams further recounted how Mayhew was considered one of the five most important people to have influenced the initiation of resistance towards Britain in the early 1760's upon the advent of new British taxes.³⁰ Mayhew's role in preparing the colonists to rebel was significant, and the most significant argument that he would make is the 1750 sermon. The "Father of Civil Liberty" truly was one of the first fathers of the country that would become the United States. The question then is what is so powerful in this one sermon that Adams would discuss its deliverer in such glowing terms?

Mayhew's Discourse Concerning Unlimited Submission and Non-Resistance to the Higher

27 Barry A. Kosmin and Seymour P. Lachman, *One Nation Under God: Religion in Contemporary American Society* (New York: Crown, 1993), 28–29.

28 John Adams, *Letters of John Adams Addressed to His Wife*, vol 1, ed. Charles Francis Adams (Boston: Charles C. Little and James Brown, 1841), 152, to Abigail Adams on August 14, 1776.

29 John Adams, *Novanglus and Massachusetts: or Political Essays Published in the Year 1774 and 1775* (Boston: Hews & Goss, 1819), 237.

30 Adams, 235.

Powers, possessed the power and prose capable of inspiring the colonists to resist tyranny. Mayhew's sermon was on Romans 13, which was used by many clergy to show that Christians, indeed all people, had to commit to unlimited submission to any governing authority regardless of how tyrannical the governing authority had become. Mayhew argued strenuously against such an interpretation and put forth principles that would inspire the rising generation of Founding Fathers. Mayhew questioned from Romans:

Here the apostle argues, that those who resist a reasonable and just authority, which is agreeable to the will of God, do really resist the will of God himself; and will, therefore, be punished by him. But how does this prove, that those who resist a lawless, unreasonable power, which is contrary to the will of God, do therein resist the will and ordinance of God?³¹

Here Mayhew sets the stage by raising the question whether the colonists have to obey a ruling authority which itself is in violation of God's ordinances for the purpose and functioning of civil government. After introducing the question, Mayhew delivered the crux of his sermon when he declared:

Thus, upon a careful review of the apostle's reasoning in this passage, it appears that his arguments to enforce submission are of such a nature as to conclude only in favor of submission to such rulers as he himself describes; i.e. such as rule for the good of society, which is the only end of their institution. Common tyrants and public oppressors are not entitled to obedience from their subjects, according to the teaching laid down by the inspired apostle.³² Considering the church's influence in colonial America, this dissertation by Mayhew is a fundamental key to the American Revolution. The idea that people have an obligation, not just a choice, to defy tyrannical authority exercised a strong influence. Mayhew challenged the colonists to look inwards and decide whether they had the courage to stand up and fight for a better country where wider freedom would prevail. Thus, Mayhew used his position of influence to sow the seeds of a new republic.

The authority of Mayhew's discourse from the lectern has been shown as significant. The decisiveness of Jonathan Mayhew on the course of the Revolution is as John Adams mused:

It was read by every body; celebrated by friends and abused by enemies... The persecutions and cruelties suffered by their ancestors under those reigns, had been transmitted by history and tradition, and Mayhew seemed to be raised up to revive all their animosities against tyranny, in church and state, and at the same time to destroy their bigotry, fanaticism and inconsistency.³³

Adams crowns this one final endorsement of Mayhew and the seeds of civil disobedience he nurtured against a potentially tyrannical government. Such a tyranny, for the colonists, would arise a few years after the sermon. In sum, Mayhew taught the colonists, especially in Boston, that they could legitimately and Biblically fight against an unjust government, and in doing so, he sowed the seeds of civil liberty in America.

³¹ Jonathan Mayhew, *A Discourse Concerning Unlimited Submission and Non-Resistance to the Higher Powers* (Boston: D. Fowle, 1750), 25.

³² Mayhew, 28-29.

³³ John Adams, *Novanglus and Massachusetts: or Political Essays Published in the Year 1774 and 1775* (Boston: Hews & Goss, 1819), 237.

Conclusion

Locke, Montesquieu, and English heritage all had an undoubtedly important influence upon American political leaders. However, the average lay person in the colonies was much more likely to have heard or read a sermon by a clergyman such as Whitefield, Mayhew, or Wise, than to thumb through Lockian pamphlets. Affirmation of the role that the clergy played in preparing America for independence cannot be overstated. Alexis De Tocqueville, a French official visiting America to observe the criminal justice system, would write in the 1830's on the connection between politics and religion:

The religious aspect of the country was the first thing that struck my attention; and the longer I stayed there the more did I perceive the great political consequences resulting from this state of things, to which I was unaccustomed. In France I had almost always seen the spirit of religion and the spirit of freedom pursuing courses diametrically opposed to each other; but in America I found that they were intimately united, and that they reigned in common over the same country.³⁴

Here, De Tocqueville simply and elegantly expresses the prescient influence of the clergy upon the life and culture of early America; this influence has been shown to trace back to the influence of these three among other gospel ministers in colonial America.

The long-time legacy of colonial clergy is well evidenced and affirmed. God's ministers led through their indirect influence in the political arena. This impact on the course of the American Revolution is a unique facet of American history and one which should be studied for an understanding of those men who were sources of America's independence. In conclusion, God's ministers, as they preached to their congregations, sowed the seeds of independence. God's patriots truly did prepare an American colonial society to fight in 1775 against the overreach of the British government.

³⁴ Alexis De Tocqueville, *Democracy in America*, vol 1, trans. Henry Reeve (New York: J. & H. G. Langley, 1835), [Ch. 17, Para 3 Gutenberg online] or (Pg. 394 in physical).

Bibliography

- "Address at the Celebration of the 150th Anniversary of the Declaration of Independence in Philadelphia, Pennsylvania | The American Presidency Project." Accessed January 9, 2023. <https://www.presidency.ucsb.edu/documents/address-the-celebration-the-150th-anniversary-the-declaration-independence-philadelphia>.
- "Benjamin Franklin on Rev. George Whitefield, 1739." National Humanities Center. Accessed January 10, 2023. <http://nationalhumanitiescenter.org/pds/becomingamer/ideas/text2/franklinwhitefield.pdf>.
- Adams, John. *Letters of John Adams Addressed to His Wife, Vol 1*. Edited by Francis Adams. Boston: Charlie C. Little and J. Brown, 1841. https://books.google.com/books/about/Letters_of_John_Adams_Addressed_to_His_Wife.html?id=15MLAAAAIAAJ.
- Adams, John. *Novanglus, and Massachusettensis; or, Political Essays, Published in the Years 1774 and 1775*. Boston: Hews & Goss, 1819. <http://archive.org/details/novanglusmassach00adam>.
- Baldwin, Alice M. *The New England Clergy and the American Revolution*. Durham: Duke University Press, 1928. <http://archive.org/details/newenglandclergy00bald>.
- Burnham, J.H. "The Birthplace of American Independence, 1687." *The Journal of American History* 9, no. 1 (1915): 440-452. <http://archive.org/details/journalofamerica09natiuoft>.
- Daily Press. "CW TO RECREATE VISIT OF FAMOUS PREACHER." Accessed January 9, 2023. <https://www.dailypress.com/news/dp-xpm-19951216-1995-12-16-9512160076-story.html>.
- De Tocqueville, Alexis. *Democracy in America — Volume 1*. Translated by Henry Reeve. New York: J. & H. G. Langley, 1835. <https://www.gutenberg.org/ebooks/815>.
- Gregg, David, W.W. Goodrich, and Sidney Carney. "Makers of the American Republic; a Series of Patriotic Lectures." New York: E.B. Treat and Company, 1905. <https://www.loc.gov/item/05001165/>.
- Jefferson, Thomas. *The Writings of Thomas Jefferson*. Washington, D.C: Thomas Jefferson memorial Association of the United States, 1905. <https://catalog.hathitrust.org/Record/006664301>.
- "Journals of the Continental Congress Home Page: U.S. Congressional Documents." Accessed January 10, 2023. <https://memory.loc.gov/ammem/amlaw/lwjc.html>.
- Kosmin, Barry, and Seymour Lachman. *One Nation Under God: Religion in Contemporary American Politics*. New York: Crown, 1993.
- Mayhew, Jonathan. *A Discourse Concerning Unlimited Submission and Non-Resistance to the Higher Powers: With Some Reflections on the Resistance Made to King Charles I. and on the Anniversary of His Death: In Which the Mysterious Doctrine of That Prince's Saintsip and Martyrdom Is Unriddled*. Boston: Robert Fowle, 1750. <http://name.umd.umich.edu/N05197.0001.001>.
- Mears, David O. *Oberlin Lectures of 1829: The Pulpit and the Pews*. Oberlin College: Edward G. Goodrich, 1892.

- Morris Benjamin F. *Christian Life and Character of the Civil Institutions of the United States*. Philadelphia: G.W. Childs, 1864. <http://archive.org/details/ChristianLifeAndCharacterOfTheCivillInstitutionsOfTheUnitedStates>.
- Oliver, Peter. *Peter Oliver's Origin & Progress of the American Rebellion*. Edited by Douglas Adair and John Schutz. San Marino California: The Huntington Library, 1961.
- Puls, Mark. *Samuel Adams Father of the American Revolution*. New York: Macmillan, 2006.
- Semple, Robert B. *A History of the Rise and Progress of the Baptists in Virginia*. Richmond: O'Lynch, 1810. <https://books.google.com/books?id=4vEpAAAAYAAJ&printsec=frontcover#v=onepage&q&f=false>.
- Sibley, John L. *Biographical Sketches of Graduates of Harvard University, in Cambridge, Massachusetts*, Vol 2. Cambridge: Charles William Sever, 1881. <http://archive.org/details/biographicalske01shipgoog>.
- Tracy, Joseph. *The Great Awakening: A History of the Revival of Religion in the Time of Edwards and Whitefield*. Boston: Charles Tappan, 1845. <https://books.google.com/books?id=RxZkYTXHc5gC&printsec=frontcover#v=onepage&q&f=false>.
- Van Tyne Claude H. *The Causes Of The War Of Independence*. Boston and New York: Houghton Mifflin Company, 1922. <http://archive.org/details/in.ernet.dli.2015.156997>.
- Wilson, James, and John Fiske. *Appleton's Cyclopedia of American Biography*, Vol. 6. New York: Appleton & Sons, 1889. <http://archive.org/details/AppletonsCyclopediaOfAmericanBiographyVol.6>.
- Wise, John. *A Vindication of the Government of New-England Churches. Drawn from Antiquity, the Light of Nature, Holy Scripture, It's Noble Nature, and from the Dignity Divine Providence Has Put upon It*. Boston: John Boyles, 1772. <http://name.umdl.umich.edu/N09928.0001.001>.

For Its Season

Lauren Dillinger

Senior, B.S., Art Education, B.F.A., Studio Art: Painting

Faculty Mentors: Tamara Brantmeier & Darren Tesar

Artist Statement

"Nature does not recognize it; she finds her own again under new forms without loss. Yet death is beautiful when seen to be a law, and not an accident. It is as common as life... Every blade in the field, every leaf in the forest, lays down its life in its season, as beautifully as it was taken up." — Henry David Thoreau, Letter to Ralph Waldo Emerson, 1842

I've lived amongst the trees all my life—overwhelmed by the temptation to look up, through, and beyond the branches toward the surrounding sky, questioning the seemingly infinite space toward the horizon. As such, I wonder: how much of this world have I overlooked, ignored, or stepped on while distracted by the soaring, living branches above? While seeking (searching) to answer this question with paint, horizonless landscapes have emerged on the surface. Moreover, the landscapes manifest themselves throughout my work as grasses, weeds, reed-like forms, and other earthly scatterings often rooted in a seasonal color palette. Furthermore, these subject matters most often represent the lifeless/forgotten/temporary forms that surround me in my everyday life. For instance, the winter weeds that flow across the surface will be trampled to the ground and overtaken by new growth, the shadows that stretch beyond the canvas will be disrupted by a footstep or fallen tree, and the ridges of snow will melt away into the soil as temperatures rise.

The gravity of paying attention in new ways has led me to recognize the unnoticed patterns that repeat themselves within one's everyday environment. For example, when given the opportunity to work/think/resolve compositions outside of the traditional rectangle, six-sided shapes reveal themselves as part of our common landscape. Whether it be a snowflake falling from the sky, the honeycomb of a beehive, or a raft of bubbles settled on a leaf, hexagons repeat themselves over and over within our surroundings while seemingly remaining unnoticed. In turn, the varying shapes of my surfaces respond to this overlooked element, and my canvas stretchers make up six-sided forms. Whether the canvas shapes are symmetrical or irregular, the potential of varying arrangements challenge the traditional Renaissance window, while the size allows for a near-life-size portrayal. Evident by the installations of different combinations of structures and materials that allow for this consideration, overlapping surfaces, faux walls, and free-standing forms emerge. Building upon the overlapping that occurs in nature in relation to the overlapping that occurs inside one's house walls, we are not unlike the natural elements that live alongside us; we are nature.

In short, I remain interested in the materiality of oil paint and various mediums, utilizing a variety of tools to apply it. Like the way in which the immediate landscapes without horizon lines had been overlooked and then later found, everyday objects are treated in a similar manner (dustpans, window scraper, brush,

etc.). While paying attention to my surroundings, I actively seek different uses for common tools. Ultimately, I watch for opportunities to intersect themes of paying attention, looking in new ways, and using my intuition as I encounter ordinary tools in my daily life in search of answers to the question: "How much of this world have I overlooked?"

My commitment to being an artist is compelled by curiosity and the desire to document, explore, and display everyday observations and experiences that I have lived, observed, touched, or stepped on. Although I remain tempted by the trees above and the horizon line they frame, I believe there is more information that lies within the unnoticed, dead, and overlooked elements of nature. By shedding light on these landscapes, my main interest remains intact--something the trees cannot overwhelm.



Withered Winter Grass

2022

Oil paint on stretched canvas, 2" x 4" studs, drywall, interior latex paint,
and wall texturing materials.

Dimensions variable.



Winter's Hay

2022

Oil paint on stretched canvas.

17" x 21"



OverShadow (Backside)

2022

Oil paint on stretched canvas, birch plywood, and pine.
Dimensions variable.



Winter's Web

2022

Oil paint on stretched canvas, pine wood, oil painting mediums.

31 ½" x 45"

Dividing the Day

Carley Holzem

Senior, B.F.A. Studio Art: Ceramics

Faculty Mentors: Kate Maury and Darren Tesar

Artist Statement

I throw functional ware out of porcelain to create large sets of pottery made for two or more people to have meals together. The experience of life can be enhanced in the simplest of ways by bringing presence and purpose to what are typically known as mundane tasks. Bringing meaning to repetitious actions creates a ceremony to look forward to every day. The love language of my pots is to bring people together through food and quality time. These sets are a simple experience waiting for someone to discover them.

My functional ware is composed of individually crafted parts that I conjoin into a whole. The base is thrown and faceted with a wiggle wire that is then shaped by my fingers from the inside. The texture rips and shapes into a new surface as it stretches while the pigmented under-glaze rests within the exposed pores. On top is a lightly tinted glaze that changes the color of the underglaze. The yellow has a red underglaze that creates a warm variation throughout the surface. The blue glaze also has a red underglaze that creates dark red and purple undertones when they are combined. The semitransparent satin white glaze is paired with a soft pink. These colors have slight variations that allow for subtle moments to admire.

The breakfast set has a quiet atmosphere in which two people will have intimate conversations. The basket has scones, and coffee will be served out of a coffee pot. The freshness of the coffee wakes up the people at the table. These moments in the morning are a time to soak up the relaxing energy of just waking up. The softness of the satin glaze comforts the person using the pots. A fun and flirty lunch is planned to bring life into a midday event. A couple join to eat fresh salad and soup to enjoy each other's company. They also have a drink to refresh their bodies before moving on with their day. Dinner is an extravagant meal that four people share together. This is a congregation for conversations and stories to be exchanged. These conversations just happen based on the people themselves. The relationships between people show through the way they are around each other.

The act of containing is ingrained into the human experience. People can use utilitarian ceramics as a way to feed themselves. I have made three specific sets that assist a person eating and drinking. I have given each pot its identity and what it will be used for during the show. I have made a fantasy for people to indulge in whether they are eating at the tables or not. It is clearly staged for the audience to consume the totality of what a functional object embodies. When a set is all together there is a preconceived understanding that there will be an event that will or already has taken place. The extravagance builds a narrative for the viewer. I will serve food to the people sitting at the tables. All the food and drinks will be contained in the ceramics I have made. Each set has an aura that embodies that meal and the experience of

feasting on that meal. Breakfast is served. Lunch is served. Dinner is served. Dining is an experience that activates many senses. This experience is elevated when there are people eating together. It becomes a communal activity that brings people together by something that everyone needs.



Breakfast

2022

Porcelain, underglaze, and glaze
Dimensions variable.



Lunch

2022

Porcelain, underglaze, and glaze
Dimensions variable.



Dinner

2022

Porcelain, underglaze, and glaze
Dimensions variable.



Dinner Trays

2022

Porcelain, underglaze, and glaze
Dimensions variable.

Glove Tips & Chimp Pits

Brodie Spolar

Senior, B.F.A. Studio Art: Comics

Faculty Mentor: Mary Climes

Artist Statement

Picture the flaccid tips of a disposable rubber glove, laboriously and unsuccessfully applied to a hand damp with perspiration. Those tips could be cut off and given to a very small man to be used as swim caps. The glove is now fairly useless, but one small man has been granted aquatic aerodynamics.

Now follow me, if you would, to a pit where there are chimps chimping hard. It does me good to see them this way. I would have been quite depressed had the pit chimps been chimping half-heartedly.

Please allow me to extend my apologies for any confusion the previous statements may have caused; don't fret--it's just art. No need to be nervous, it won't aggressively spunk on your trousers if you startle it; the art can be quite docile. In fact, art is like farts, easy to rhyme and a bodily function that is societally discouraged. You may have even experienced a whole variety of symptoms from holding in your arts.

In my own artistic practice, I seek to express my art glands by exploring the intersections of art and functioning. By functioning, I mean the processes and experiences that make up being a human. As I go about being a human, I become more and more fascinated with the areas where art appears in my daily life, like patches of mold. My artistic practice is not progress-based; it is an attempt to rein in and understand this bodily function. Art moves slower than life tends to, requiring careful listening and patience to recognize. This conjunction of art and functioning, when observed, results in immensely satisfying gestalts. I refer to this phenomenon as the Asynchronous Semiotic System (ASS) which opens up unprecedented modes of ingesting and emitting reality. A piece of roasted broccoli will fuel and inform a drawing the next day, but it is in the broccoli that I see the art.

My exploration of art emanating into the world extends into my drawing. I am not an innately nimble or talented artist in the context of image making; my motor skill capacity restricts my line quality to dense or extra dense. With images simplistic to the point of being easily replicable, I use bold and humorous imagery to lure cheap emotions such as incredulity and frustration out of viewers. If you make somebody laugh, you have created an opening, an in-road to more complex and Sotheby's-approved emotions. I recycle forms and ideas, presenting them in different ways to observe what reactions they might elicit, as the reaction is where the art lies. This network of forms and reactionary-based drawing is a portion of my practice that I refer to as Person Oriented Ontological Practices (POOP). I attempt to harness the more easily accessed human responses such as laughter or discomfort to create weak points in the viewer's façade through which more poignant responses can be accessed.

Now that was pretty dense, and I feel like I was talking a lot about myself. Let's take a step back. Look at that little man go! Turns out all he needed was a few good swim caps to really take to aquatic sport with a fervor. That's all well and good for the small swimmer man, but one might question his inclusion in this statement. Let me assure you, the small man in the medical glove swim cap exists primarily as a glibly calculated deflection of sincerity. Sincerity and self-seriousness are an important aspect of my artistic practice, keeping honesty at an arm's length and a general tone of detached aloofness signify a pretentious aesthetic. This carefully cultivated pretense is an important musk that serves to mask the fact that I haven't a clue what I'm doing. This is what I refer to as Selected Coding Resulting in Overt Tone and Empathy (SCROTE).

In summary, I don't want to make art, I just want to cook. I draw bugs that aren't about bugs. If this all seems a bit insincere and contrived, don't worry—it's just art. Now if you would excuse me, the chimp pit has gone quiet, and I must go investigate.



To Be in Contact (With), Under a Rotten Log
2022
Other people, crayon.



I Should Have Been Making Art

2022

Water, kombu, shiitake mushrooms, miso, garlic, ginger, shoyu, onion, potato, cabbage, scallions, shallots, tofu, tomato, noodles, oat milk, vegetable oil, salt, Post-it Note, Micron pen.



Wormin' Out
2022

Crayon, pen, and a bleak urinalscape.

The strewn evidence meant something

Zach Zajda

Senior, B.F.A. Studio Art: Painting; Minor: Art History

Faculty Mentors: Daniel Atym, Morgan Barrie

Artist Statement

"There's been time this whole time. You can't kill time with your heart. Everything takes time. Bees have to move very fast to stay still." —David Foster Wallace, *Forever Overhead*

I believe in art as evidence. As a record of time and kinesis and a respite from the noise of each. My current work searches for personal, visual affirmations which lie in the poetics between representation and abstraction. I seek imperfect tautologies: self-evident statements undermined and obscured by the way they are told. Unities of content and form which appear unintelligible at a glance while hiding rarer truths. Ultimately, I rely on the mediation and crystallization of time while asserting luck, improvisation, and dreams as the only guiding principles one can authentically trust.

And though I embrace ambiguous irresolution, I am not immune to the comforts of clarity. If there is one thing I hope my art might advocate, even if only by arrangement in color and composition, it is that we should live in softer worlds. Worlds with less pain—less perjury—and more beauty.

Studio Painting II presents an interior scene punctuated with seated figures (painted from life). The piece is composed of two separate paintings of the same location which began on isolated sheets of paper. These initial works were cut into pieces and assembled—along with additional scraps of paper—into a larger, fragmented context. After stapling this refreshed composition into place, I continued to modulate the painted space and the people within it until an unanticipated level of finish revealed itself.

The Garden and at left arose from imagined still life objects and spaces. Furniture, fruit, and mundane objects within lightful interiors provided a stage for the exploration of intuitive mark-making and its opposite. As I scribbled, every successive mark tried to rule out the one that preceded it and proffer a new image, connotation, or allusion elsewhere in the composition. Working in this way, I reflexively attempted to undo, redo, and get lost. Moments of pleasant surprise in the form of humor and beauty abstracted my imagined, illusive objects and made them mean multiple things. Somehow, this natural embodying of energy distilled lucidity.

Pure Hollywood sought to remember, glorify, and satirize a scene of communal consumption—a distinct moment in time. My frenetic use of varied mediums allowed the work to grow and change. Layering over my favorite sections of the painting with fresh paper introduced chance, levity, and the conviction that nothing was lost so long as it remained underneath.



Studio Painting II

2022

Oil and graphite on paper stapled to board.

48" x 48"

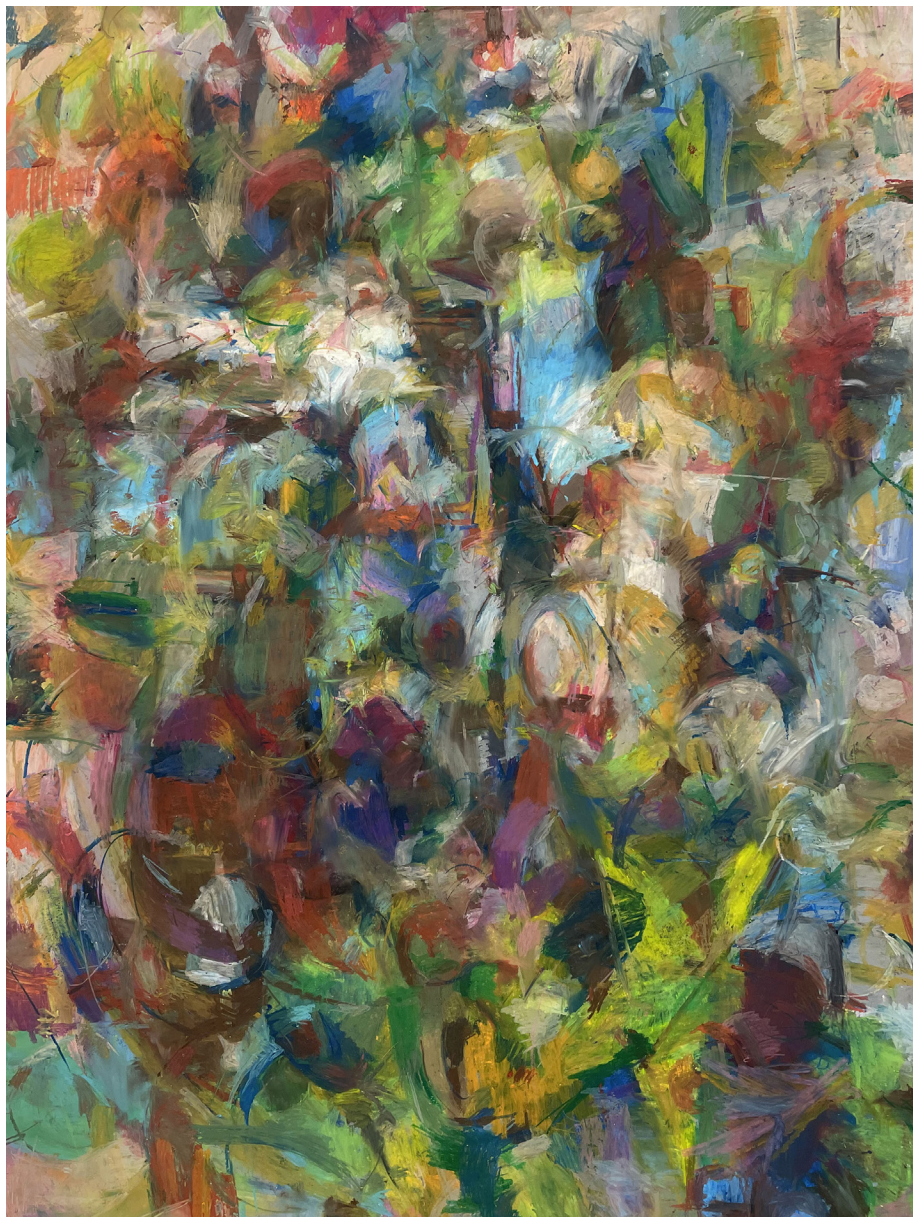


The Garden

2022

Tempera on cardboard.

11" x 15"



at left

2022

Oil pastel on paper.

34.5" × 46"



Pure Hollywood

2022

Acrylic, chalk pastel, oil pastel, charcoal, and tape on paper.

48" x 84"

